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FOR THE

PROMOTION OF THE MECHANIC ARTS.

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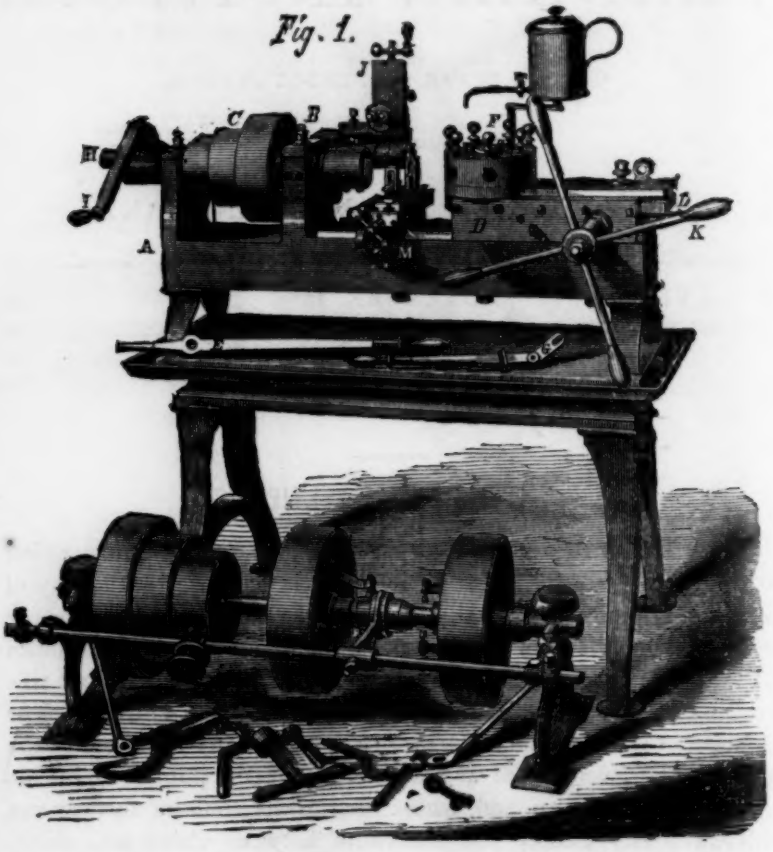
EDITORIAL.

ITEMS AND NOVELTIES.

New Railway across Egypt.—We observe that the opening of the new route by rail from Alexandria to Suez, by the way of Zagazig, is announced as having taken place last month. The former route was by rail from Cairo to Suez, the distance from Alexandria to Cairo being traversed by canal and the Nile, or by rail; but this making a considerable detour, and lengthening the journey. The relation of these routes can be well understood by reference to the map of the Suez Canal and adjacent country, published in this *Journal*, Vol. LV., p. 236, where the railway route of former use follows pretty closely the post-route between Cairo and Suez, through a very rough and difficult country, while the portion of the new line which corresponds with this, from Zagazig to Suez it will be seen, avoids these natural difficulties, by skirting the elevated ranges in place of crossing them, and yet makes a much more direct line between the terminal stations. The entire length of the new route is eighty-five miles.

Screw Cutting Machine. By Brown & Sharpe, Providence, R. I. We give below a drawing and description of a machine, which has now been in use in many of our best workshops for a sufficient time to establish its merit as a most efficient and valuable tool. Its quality as regards saving of labor and consequent economy, in comparison even with machines otherwise employed for similar work, appears from this, that one man with such an apparatus can

Fig. 1.



produce as many screws as from three to five can make, on as many engine lathes.

The bed, A, which is of cast iron, is very heavy, and has at one end two uprights cast solid with it, containing bronze boxes to support the spindle. The front box, B, is made in four parts, that it may be closed up to compensate for wear, the two middle pieces

SUGAR INSECT.

"Acarus Sacchari."

FOUND IN RAW SUGAR.

Fig. 1.

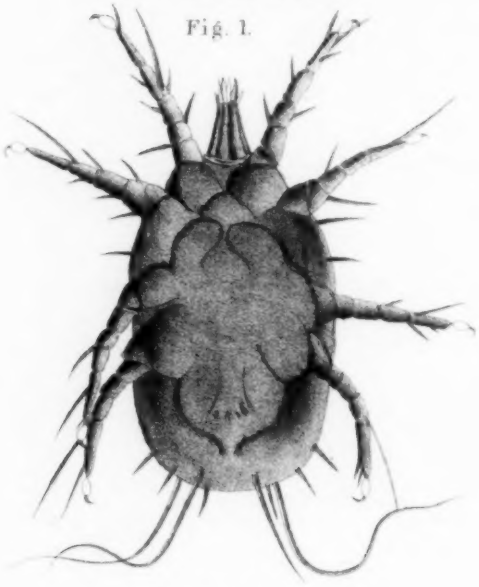
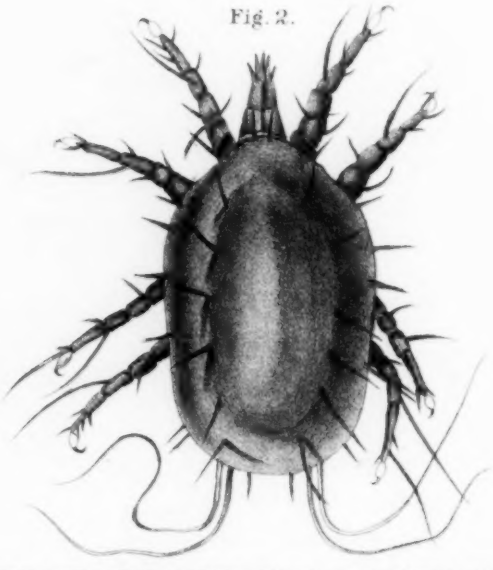


Fig. 2.



DRAWN FROM LIFE FROM INSECTS FOUND IN GROCERY MAURITIUS SUGAR.

By Smith, Beck & Beck, Microscopists, London.

Bowen & Co. lith. Phil.a

being forced in horizontally towards the centre of the spindle by the screws on each side of the box. The spindle is of steel, and has only one flange or collar, which is outside of the front box. Between this flange and the end of the box is a hardened steel washer. The cone pulley, C, is kept from turning on the spindle by a spline. Back of the pulley is a nut by which it can be forced forward and its hub kept up to the rear end of the front box. By these devices, the front journal can readily be kept tight, though considerable wear should take place. Should the spindle heat by continued use, it will not bind end-wise, nor will its expansion length-wise affect the accuracy of the work done on the machine. The spindle is hollow, the hole being one and a quarter inches diameter, and has on the front end a steel chuck, with screws and jaws for adjusting and holding the iron bar or wire from which the screws are made. On the rear end of the spindle is a leading screw, and in the hand-lever, I, a section of a nut, which fits into this screw. The bar, II, is fitted to slide end-wise in bearings parallel to the spindle, and carries on its front end a tool-head, J, and to the rear end the lever, I, is attached. A screw thread can be cut with this device on a bar projecting from the chuck on the front end of the spindle, with a tool held in the head, J, on the front end of the bar, H. At the other end of the bed of the machine, resting upon two V-shaped ways, is a rectangular piece, D, which can be fastened at any point by two screws from underneath. Upon and attached to this is another piece, which is fitted to slide in a direction parallel to the bed, and is moved by the hand-wheel, K, connecting by means of a pinion and rack, or, for light work, by the hand-lever, E, substituted for the hand-wheel, K. On the end of this sliding piece, nearest the spindle, a round head, F, is so arranged as to revolve horizontally. In the edge of this head are seven holes, which serve to hold the mills, cutters, and dies used in making screws. The head is held very firmly in its place, while the cutters are operating by a steel pin, which comes up through the piece on which the revolving head rests, at the point nearest the line of the spindle. This pin is hardened and slides through a hardened steel bushing, and the upper end, which is tapered, enters into hardened bushings in the bottom of the revolving head. These steel bushings are ground inside and out, after hardening, and the pin is afterwards ground into them so that the point fits them all alike. When the revolving head is moved back, this pin is withdrawn by means of a short lever,

the fulcrum of which is attached to the sliding piece which supports the revolving head, one end being connected with the pin, and the other striking an inclined plane in the lower piece, D, which is fastened to the bed. The extreme back motion given to the sliding piece carrying the revolving head by the hand-wheel, K, brings a star wheel on the under side of the revolving head in contact with a dog, projecting upward from the lower piece, D, which causes the head to revolve far enough to bring the next tool in a position ready to operate on the screw. When the revolving head is brought forward, the star wheel slips over the dog, and the pin enters the hole in the head, being forced up by a spring acting on the rear end of the short lever, after which the tool commences to operate.

There is an arrangement whereby any wear in the centre hole of the revolving head can be compensated for, and there are two gibs, one on each side of the sliding piece, carrying the revolving head, to adjust its position or to close up for wear. At the outer end of the sliding piece, projecting underneath it, is a screw, L, which can be set to limit its motion. The tools in the revolving head are each held by two screws, by which they can be adjusted as required for the different cuts on the work. Shoes are inserted underneath these screws to prevent the tools they hold from being injured. Between the spindle and revolving head and attached to the bed, is a slide rest operated by a crank, M, attached to a screw, or for light work, by the hand-lever, G. It has two tool-posts, one at the back, sliding in a groove parallel with the ways of the machine, and one in front, sliding in either one of two grooves, side by side, but which are at right angles with the one at the back end. Both of these tool-posts can be raised or lowered to adjust the tools. The bottom piece of this rest is planed on the ways of the bed, and can be moved upon them to any position required. The tools in this rest may be used for cutting off, pointing, or grooving, and their movements may be limited by set nuts upon a screw underneath the rest. Oil is supplied from the can placed above the revolving head, to the cutting tools, when the machine is in operation. The machine is set upon an iron table, having a channel around the edge to catch the oil, which is conducted by tubes to a pail hung underneath the machine. The overhead work, which is shown in a reversed position on the floor in front of the machine, has two of Brown's patent friction pulleys, by which the motion of the spindle can be changed at will.

Standard Wire Gauge.—The importance of a uniformity in standards for all things which have any extended use, is a matter both so self-evident, and so frequently noticed of late years, that we consider any comment would be superfluous. The only open question is that of selecting a standard which shall have the merits of convenience, ease of construction and verification, and accordance, if possible, with the best usage.

These were some of the points discussed by the Committee of the Franklin Institute, who had in charge the question of a standard gauge for screws and nuts, and it is with reference to these, that we should consider any similar arrangegement having regard to another standard of an article in general use.

No. of Wire Gauge.	New Standard		Old Standard.	
	Size of each No. In dec. parts of an in.	Diff. bet. cons. Nos. In dec. parts of an in.	Size of each No. in dec. parts of an in.	Diff. bet. cons. Nos. in dec. parts of an in.
0000	·460	.....	·454	.....
000	·40964	·05036	·425	·029
00	·36480	·04484	·380	·045
0	·32495	·03994	·340	·040
1	·28930	·03556	·300	·040
2	·25763	·03167	·284	·016
3	·22942	·02821	·259	·025
4	·20431	·02511	·238	·021
5	·18194	·02237	·220	·018
6	·16202	·01992	·203	·017
7	·14428	·01774	·180	023
8	·12849	·01579	·165	·015
9	·11443	·01406	·148	·017
10	10189	·01254	·134	·014
11	·09074	·01105	·120	·014
12	·08081	·00993	·109	.011
13	·07196	·00885	·095	·014
14	·06408	·00788	·083	·012
15	·05707	·00702	·072	·011
16	·05082	·00625	·065	·007
17	·04526	·00556	·058	·007
18	·0403	·00495	·049	·009
19	03589	·00441	·042	·007
20	·03196	·00393	·035	·007
21	·02846	·00350	032	·003
22	·02535	·00311	·028	·004
23	·02257	·00278	·025	·003
24	·0201	·00247	·022	·003
25	·0179	·00220	·020	·002
26	·01594	·00196	·018	·002
27	·01419	·00174	·016	·002
28	·01264	·00155	·014	·002
29	·01126	·00138	·013	·001
30	·01002	·00123	·012	·001
31	·00893	·00110	·010	·002
32	·00795	·00098	·009	·001
33	·00708	·00087	·008	·001
34	·0063	·00078	·007	·001
35	·00561	·00069	·005	·002
36	·005	·00061	004	·001
37	·00445	·00055	.....	.....
38	·00396	·00049	.....	.....
39	·00353	·00043	.....	.....
40	·00314	·00039	.....	.....

At the last meeting of the Institute, some remarks were made on this subject, in connection with several instruments for measuring the thickness of wire and sheet metals manufactured by Messrs. Brown & Sharpe, of Providence, R. I., which were exhibited on the occasion. These gentlemen have arranged, and have caused to be already pretty largely adopted, a standard wire gauge, known as the "American gauge," which seems to fulfill in a very satisfactory manner the various requirements of the case.

In this scale, the starting point is taken at No. 36, which represents a diameter of ·005 of an inch, and this quantity being multiplied by ·0503536, gives the next size, or No. 35, and this product being again multiplied by the same factor, ·0503536, gives the next size, or No. 34, and so on for each successive size above, while the smaller sizes are obtained similarly by dividing ·005 of an inch, and the quotients obtained successively by this same number.

The accompanying table shows the numbers so obtained for the new scale, as compared with the sizes of the old one.

By this means it will be perceived that the sizes vary in a regular geometrical progression, which produces a very gradual change in size for the smaller diameters, but a rapidly increasing difference as the larger ones are reached. This is evidently, exactly what is demanded in practice.

Fig. 1.

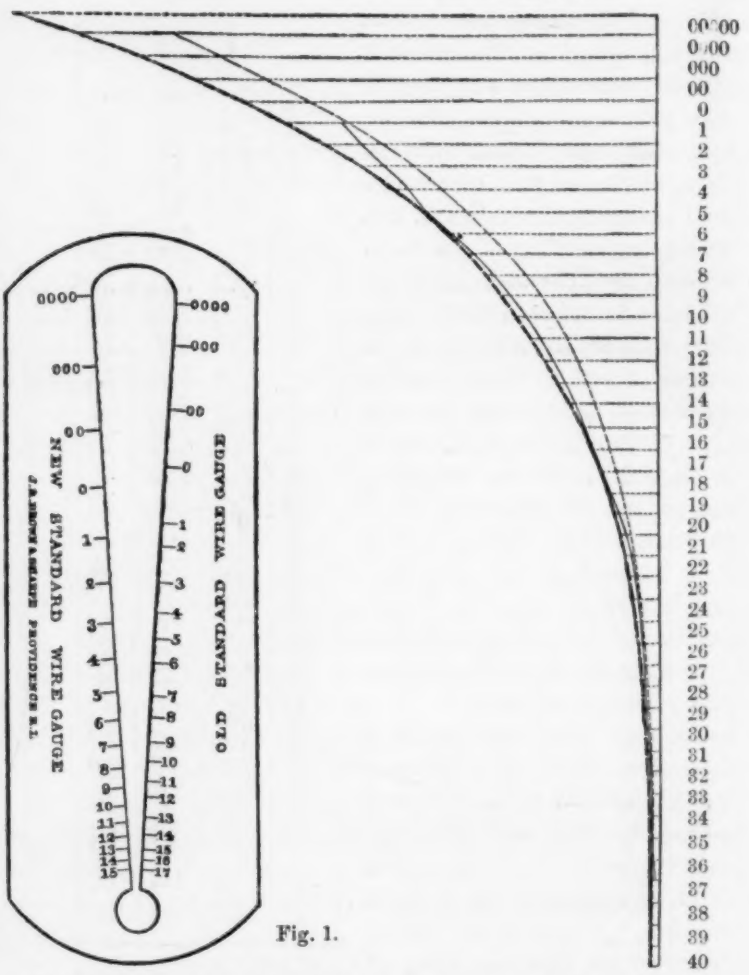


Fig. 1.

This relation is well exhibited by the graphical projection in Fig. 1, where the different numbers being indicated by the successive distances upon the vertical line, the relation of the correspond-

ing sizes is set off on the corresponding horizontal lines, and a line then struck through the terminal points. Thus, the light dotted line represents the result of this process for the Brown & Sharpe gauge; the heavy dotted line, that derived from a very similar gauge, proposed by Mr. Latimer Clark, and the very irregular full line, the state of relations in the common or Birmingham gauge, as given by Holtzapfell.

WEIGHT OF WIRE AND PLATES, AS PER AMERICAN GAUGE.

No. of Gauge.	Size of each No.	Weight of Wire, per 1000 Lineal Feet.				Weight of Plates, per Square Foot.			
		Wro't Iron.	Steel.	Cop'r.	Brass.	Wro't Iron.	Steel.	Cop'r.	Brass.
	Inch.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
0000	·46000	560·74	566·03	640·51	605·18	17·25	17·48	20·838	19·688
000	·40964	444·68	448·88	507·95	479·91	15·3615	15·5663	18·557	17·533
00	·36480	352·66	355·99	402·83	380·67	13·68	13·8624	16·525	15·613
0	·32486	279·67	282·30	319·45	301·82	12·1823	12·3447	14·716	13·904
1	·28930	221·79	223·89	253·34	239·35	10·8488	10·9934	13·106	12·382
2	·25763	175·89	177·55	200·91	189·82	9·6611	9·7899	11·671	11·027
3	·22942	139·48	140·80	159·32	150·52	8·6033	8·7180	10·393	9·8192
4	·20431	110·62	111·66	126·35	119·38	7·6616	7·7638	9·2552	8·7445
5	·18194	87·720	88·548	100·20	94·666	6·8228	6·9137	8·2419	7·787
6	·16202	69·566	70·221	79·462	75·075	6·0758	6·1568	7·3395	6·9345
7	·14428	55·165	55·685	63·013	59·545	5·4105	5·4826	6·5359	6·1752
8	·12849	43·751	44·164	49·976	47·219	4·8184	4·8826	5·8206	5·4994
9	·11443	34·699	35·026	39·636	37·437	4·2911	4·3483	5·1837	4·8976
10	·10189	27·512	27·772	31·426	29·687	3·8209	3·8718	4·6156	4·3609
11	·090742	21·820	22·026	24·924	23·549	3·4028	3·4482	4·1106	3·8838
12	·080808	17·304	17·468	19·766	18·676	3·0303	3·0707	3·6606	3·4586
13	·071961	13·722	13·851	15·674	14·809	2·6985	2·7345	3·2598	3·0799
14	·064084	10·886	10·989	12·435	11·746	2·4032	2·4352	2·9030	2·7428
15	·057068	8·631	8·712	9·859	9·315	2·1401	2·1686	2·5852	2·4425
16	·050820	6·845	6·909	7·819	7·587	1·9058	1·9312	2·3021	2·1751
17	·045257	5·427	5·478	6·199	5·857	1·6971	1·7198	2·0501	1·937
18	·040303	4·304	4·344	4·916	4·645	1·5114	1·5315	1·8257	1·725
19	·035890	3·413	3·445	3·899	3·684	1·3459	1·3638	1·6258	1·5361
20	·031961	2·708	2·734	3·094	2·920	1·1985	1·2145	1·4478	1·3679
21	·028462	2·147	2·167	2·452	2·317	1·0673	1·0816	1·2893	1·2182
22	·025347	1·703	1·719	1·945	1·838	·95051	·96319	1·1482	1·0849
23	·022571	1·350	1·363	1·542	1·457	·84641	·8577	1·0225	·96604
24	·020100	1·071	1·081	1·223	1·155	·75375	·7638	·91053	·86028
25	·017900	0·8491	0·8571	·9699	0·9163	·67125	·6802	·81087	·76612
26	·01594	0·6734	0·6797	·7692	0·7267	·59775	·60572	·72208	·68223
27	·014195	0·5340	0·5391	·6099	0·5763	·53231	·53941	·64303	·60755
28	·012641	0·4235	0·4275	·4837	0·4570	·47404	·48036	·57264	·54103
29	·011257	0·3358	0·3389	·3835	0·3624	·42214	·42777	·50994	·48180
30	·010025	0·2663	0·2688	·3042	0·2874	·37594	·38095	·45413	·42907
31	·008928	0·2113	0·2132	·2413	0·2280	·3348	·33926	·40444	·38212
32	·007950	0·1675	0·1691	·1913	·1808	·29813	·3021	·36014	·34026
33	·007080	0·1328	0·1341	·1517	·1434	·2655	·26904	·32072	·30302
34	·006304	0·1053	0·1063	·1204	·1137	·2364	·23955	·28557	·26981
35	·005614	·08366	·08445	·0956	·09015	·21053	·21333	·25431	·24028
36	·005000	·06625	·06687	·0757	·0715	·1875	·19	·2265	·2140
37	·004453	·05255	·05304	·06003	·05671	·16699	·16921	·20172	·19059
38	·003965	·04166	·04205	·04758	·04496	·14869	·15067	·17961	·1607
39	·003531	·03305	·03336	·03775	·03566	·13241	·13418	·15995	·15113
40	·003144	·02620	·02644	·02992	·02827	·1179	·11947	·14242	·13456
Specific Grav....		7·7747	7·847	8·880	8·386	7·200	7·296	8·698	8·218
Weight per Cubic Foot.....		485·874	90·45	554·988	524·16	450·	456·	543·6	513·6

The Specific Gravities to determine the weights, and the calculation of them, were taken and made by Charles H. Haswell, 6 Bowling Green, N. Y. Diameters and thickness determined by the American Gauge, which is introduced and manufactured by J. R. Brown & Sharpe, of Providence, R. I. This gauge is now very extensively adopted among manufacturers of wire and plates. It should be considered the standard American gauge. To be had in the principal hardware stores in the country.

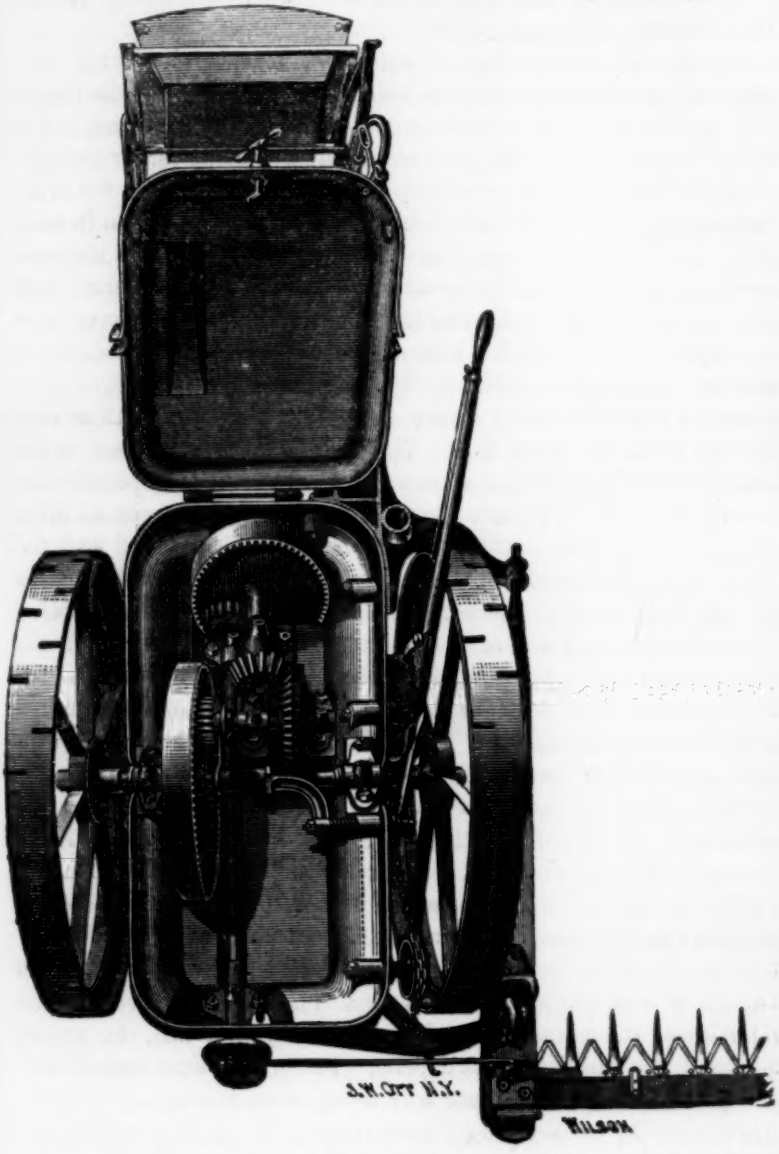
The great want of regularity in the common gauge, as compared with this new one, is also exhibited by Fig. 2, which shows one side of one of the many forms in which wire gauges are prepared by Messrs. Brown & Sharpe, and in which the numbers by both old and new gauges can be taken at once and compared.

The subjoined table, which has been prepared with great care, gives the weight of all sizes of wrought iron, steel, copper and brass wire and plates whose diameter or thickness has been determined by the American Gauge.

Harvesters.—To America belongs the honor of first successfully producing the mowing and reaping machines. When first introduced, although their form was awkward and cumbersome, yet their practical usefulness was fully demonstrated, and the inventive genius of our country has ever since been encouraged to persevere in efforts at improvements, adding one important feature after another, until the Harvesters of to-day are among the most perfect and satisfactory labor-saving machines of which the age can boast. The State of Ohio stands foremost in the field as a manufacturer of Harvesters, having a large capital invested in that branch of agricultural machinery.

To a person crossing the State, along the line of the Pittsburg, Fort Wayne and Chicago Railway, it is a source of surprise to notice, in passing the different towns, the large shops devoted exclusively to agricultural machinery. Of late years, the machinists of Ohio have devoted a great share of labor, time and money to perfecting the Harvesters, and in their shops we find the tools, the arrangements and appointments such as cannot be surpassed in any establishment in the country. A good example of such works is furnished by the shop of E. Ball & Company, Canton, Ohio; and some of the improvements introduced by this firm will, we think, be interesting to our readers. To Col. E. Ball, of Canton, Ohio, is conceded the honor of having produced the first successful two-wheeled Harvester ever built—the old *Ohio*—and several years were spent with constantly increasing resources and facilities in manufacturing and perfecting that justly popular machine. It soon became evident to the constructors that the mechanical standard of the Harvester must be elevated if it was to keep pace with the rapid march of improvements, which characterizes our day, and fully meet the constantly increasing tax upon its durable qualities. Each year's experience and observation rendered it more apparent

that however well made, the rough-cast Harvesters could not be built to meet their new conditions, and it was therefore determined



to produce a new machine upon wholly different principles, with the belief that the increasing intelligence, wealth and enterprise of

the country would insure the success of the undertaking. The *World's Harvester* is the result of that determination.

The features of this machine are first, That all parts of various machines are interchangeable.

Second. That the wheels are cast *blank*. As this is a point of vital moment, we wish the reader to note it particularly. These blanks are as perfect as it is possible to make a casting of any kind, but in order to secure *absolute* perfection, they are made larger than the wheels intended to be produced from them, to provide for every contingency attending their moulding, and the contraction in cooling. They are then placed in a lathe and turned off to the standard gauge. After being turned down to the required size, faced and bored, they are passed to the gear cutters. These have been invented and built by the manufacturers expressly for this work, and are thoroughly efficient. The blanks are firmly adjusted in position, and then with a steady measured stroke, the teeth or cogs are cut from the solid iron. The cutting of every wheel in the machine is effected in the same manner, so that it is impossible for the wheels to be imperfect in any respect, or for one cog to differ from another. The shafting of this machine is prepared with the same regard for exactness in all its relations, as that which marks the preparation of the gearing, each piece with its journals being turned to a gauge and of a size which when driven through the bore of the wheel, of which it is the axis, does not admit of the slightest vibration of either shaft or wheel. Although the adjustment of the shafts and the boxes of the several wheels is so firm that they seem to be a single piece, the connection is rendered additionally secure by the introduction of keys sunken into both wheel and shaft. Each wheel with its cogs, and shaft with its journals, having been thus prepared, the next important matter is to adjust them to each other in a frame which will preserve them in the exact positions and relations they are intended to occupy. The foundation of the *world's machine*, like that of all structures intended to endure, is arranged with especial care. The frame of a reaper is its *foundation*, and upon the solidity and strength of *this*, the proper action of the working parts depend. In moving over uneven surfaces, it is obvious that there will be more or less strain upon the frame, thereby endangering the bearings of the gearing attached to it. Heretofore, machines were built with light iron or heavy wooden frames, neither of which can entirely resist the strain to which they are subjected while the latter is exposed to the additional disadvan-

tages arising from expansion, contraction and warping, thereby seriously affecting its permanency, as well as that of the bearings, &c., and it is equally obvious that the slightest derangement of the lines of action, throws the whole gearing out of adjustment, and increases the friction.

To avoid these difficulties, the foundation of this machine consists of a *single piece of iron*, so shaped that there can be no strain or torsion in any direction, which is not fully provided for. This foundation or *case*, while it furnishes an unchangeable base for the gearing, answers the further purpose of entirely excluding water, dirt, grass, and indeed, everything else that is calculated to prove injurious to the machinery; since it has not only a seamless bottom, but also a closely fitting hinged top. The bearings of the machine are fixed with the greatest exactness, because, upon this depends an accurate operation of the gearing. First, a jig or skeleton, representing all the journals, is laid in the hold or frame, and the bearing filled with Babbitt metal. Three important ends are secured by this process. First, the *lines* of the machine are secured with great precision, the exact place for the centre of each journal is fixed, and thereby the relative position of each shaft and wheel is determined. Second, each one being adjusted by the same standard, all are precisely *alike*. Third, the Babbitt metal affords its usual good effects. The boxing is all "Babbitted," drilled and turned to a standard gauge. Not only are the holes bored and the bolts turned, so that the fit is perfect, but the threads of the bolts are cut upon a lathe, so that when forced into their place and secured with nuts faced in the same manner as the bolt-heads and bearings, there is not a possibility of lateral movement. The permanency of the boxing is further secured by the fact that each box is "stooled" or sunk into the "pillar-block," the connection being carefully bored and turned. Under each of these "stools," there are a number of tin washers, which can be removed one by one, as the wear of the metal may require.

With this arrangement for re-adjustment, it is possible to keep the journals, and hence the cogs of the wheels, in their proper relation to each other. Thus each of the several parts from the tin washer underlying the "stools," to the largest wheel or shaft, is perfect in form and adjustment, and enclosed in a neat iron case, in which it is perfectly secured from all external causes of destruction.

Mr. Boyle and the Zentmayer Lens.—We make, with great willingness, at the request of Mr. Boyle, the following explanations

with the view of avoiding a misunderstanding of our notice in the September number:—1st. The charges alluded to as "slanders" were made by the editor of *Humphrey's Journal* not by Mr. Boyle. 2d. The conclusion we draw from the facts stated in connection with the action of the New York Photographic Society is, that the whole affair was managed without the least care or attempt to reach the facts of the case. So, only, can we reconcile the report with the documentary evidence in our possession, and the drawings published by Mr. Boyle himself in his letter.

Hydraulic Lift Graving Dock for Bombay.—One of these docks, invented by Mr. Edwin Clark, is, as we learn from *Engineering*, about to be constructed in England and sent out to India, this form being specially fitted for the purpose, by reason of its economy in first cost and working expenses, and because it can be erected in a very short time, as compared with other forms. The dock will be formed of thirty-six cast iron columns, six feet six inches in diameter, placed in parallel rows ninety-four feet six inches apart, from centre to centre, eighteen columns being arranged equidistantly in each row.

The lower part of each column will be let into the ground to such a depth as may be necessary, in order to secure a good foundation, the height from the ground to the top of the columns being eighty-seven feet. The dock has been designed with a view to its being erected where there is an extreme depth of water at high tide of forty-eight feet six inches, and the columns will rise thirty-eight feet six inches above that level. The bottom of each column is filled in with concrete, to a height of about twelve feet above the ground level; on this is laid a seating of timber to receive the bedplates of the hydraulic presses. Each column contains two hydraulic presses, having fourteen inch rams, with a stroke thirty-three feet six inches in length. The upper ends of the two rams are connected to a wrought-iron cross-head, from either end of which depend chains, connected at their lower extremity with the girders supporting the pontoon. The upper portion of the cast iron columns are of Tuscan character, and those in each row are connected at their tops by a platform carrying a traveller. There is also a platform twenty feet wide, just above high water line, surrounding the dock, excepting at its entrance end. For the purpose of enabling the pontoon to be canted in various directions, the columns are arranged in three groups, each group being capable of being worked independently of the other two; thus, the first nine columns

on each side form one group, and the other nine columns on either side form the other two groups respectively.

The pontoon rests upon iron trellis girders, ten feet eight inches deep and ninety-six feet three inches in extreme length. The top and bottom members of these girders are connected together; the struts, consisting each of two parallel flat bars braced together, and the ties of a number of thinner bars. The girders are arranged in pairs, connected together at their top flanges by cross bracing.

The pontoon is 380 feet long by eighty-five feet wide, and it rests upon balks of teak timber laid on the top of the girders. The extreme depth of the pontoon at its sides is nine feet eight inches, and it slopes down to a depth of six feet eight inches in the centre; the centre of the pontoon is thus made shallower than its outside, with a view to enabling it to be used for vessels of greater draught. A flap at the entrance of the pontoon, thirty feet wide, lets down for the admission of vessels, and is then closed up water-tight against india-rubber, bringing the height of the entire end straight on a level with the sides. The pontoon consists of a frame work formed by three longitudinal box girders extending its whole length, in addition to the outsides, and these are connected transversely by forty-nine cross girders, the whole being covered with plates half inch thick. It is also divided internally into thirty-six water-tight compartments, each provided with a separate valve, so that it can be filled with water, if required, to prevent the straining of the pontoon by unequal loading.

The whole iron work in this fine structure will weigh about 7,000 tons, of which the pontoon alone takes 1,500 tons. For the convenience of shipment it has been found necessary to limit the weight of each piece of the structure, and the pontoon will have to be completed by riveting the parts together on their arrival at Bombay.

The engines for working the hydraulic rams will consist of two pairs of high-pressure horizontal cylinders, each twenty-two inches in diameter, with a two feet six inch stroke. These engines will work twenty-four pumps, having the same length of stroke, and with plungers two and a quarter inches in diameter. These engines will be capable of lifting the Bellerophon, on a suitable pontoon, thirty-three feet high in less than an hour, the total weight of that ship and its pontoon being, together, equal to about 11,000 tons.

Structure of the Sun.—Some points of interest and novelty in connection with the above subject, appear in two articles which we have just received in the last published number of the *Proceedings*

of the Royal Institute, No. 46. These articles are first, "On the Sun as a variable star." By Mr. Balfour Stewart, and second "On the Chemistry of the Primeval Earth." By Mr. T. Sterry Hunt.

The first author, after a preliminary discussion, and disposal of the various unsatisfactory hypotheses which have been suggested in explanation of the phenomena of variable stars and periodicity in sun spots, proceeds to enunciate, in a concise form, a theory not unfamiliar in many points but now most completely expressed.

The photosphere or visible surface of the sun, is conceived, as in most modern theories, to consist of cloud masses, or to be a surface of condensation terminating the ascending currents of vapor which are constantly rising from the central mass. The faculæ or portions of superior brightness often observed and frequently accompanying sun spots, are portions of this cloudy matter which have reached an excessive height in the solar atmosphere and thus escape the absorbing or light-obscuring influence of that medium.

The fact that these facula as a rule predominate on the following side of a spot, indicates to us that they have been projected from a lower to a higher region, and thus, by reason of their slower motion, fall behind in the more distant and therefore more rapidly moving regions into which they have been projected, exactly on the same principle which explains the westerly motion of our trade winds.

On the other hand, as shown by the observations of Carrington, sun spots have a forward motion with reference to the adjacent regions of the surface, thus indicating that the influence producing them has descended from a higher and more rapidly moving region, This influence Mr. Stewart supposes to be a down-rush of the colder and absorbtive atmosphere which follows the explosion or uprush by which the faculæ were projected outwards.

Such being the nature of sun spots, the cause of the periodicity is next examined, and it is shown, from the observations of Messrs. De la Rue, Stewart and Loewry, which we have before noticed, that the period of ten years, now well established, depends upon the influence of the two planets, Venus and Jupiter; the one being effective by reason of its nearness, and the second by its mass.

As a complement and conclusion to this description, we may well insert the substance of Mr. Hunt's paper, where he speaks of the solar constitution.

After drawing attention to the facts demonstrated recently by Deville, as regards the decomposition of the most fixed chemical compounds by a very high temperature, he proceeds as follows:

"The sun, then, is to be conceived as an immense mass of intensely heated gaseous and dissociated matter, so condensed, however, that, notwithstanding its excessive temperature, it has a specific gravity not much below that of water; probably offering a condition analogous to that which Cagniard de la Tour observed for volatile bodies when submitted to great pressure at temperatures much above their boiling point. The radiation of heat, going on from the surface of such an intensely heated mass of uncombined gases, will produce a superficial cooling, which will permit the combination of certain elements and the production of solid or liquid particles, which, suspended in the still dissociated vapors, become intensely luminous and form the solar photosphere. The condensed particles, carried down into the intensely heated mass, meet with a heat of dissociation; so that the process of combination at the surface is incessantly renewed, while the heat of the sun may be supposed to be maintained by the slow condensation of its mass; a dimunition by $\frac{1}{1000}$ of its present diameter being sufficient, according to Helmholtz, to maintain the present supply of heat for 21,000 years."

This hypothesis is due, as our author remarks, to Faye, and seems to accord best with our present knowledge. It is especially worthy of note that it accords with the observed fact, that the intensity of the sun's emitted rays corresponds with those derived from chemical combination, while other considerations would lead us to assign the primary source of the solar temperature to a much more intense origin, such as the heat developed by impact of meteoric matter, a source omitted, but not excluded, in the above hypothesis.

Photograph of Invisible Light.—We have just received, through the kindness of a friend, a photograph of the actinic portion of the solar spectrum, showing the absorption bands (as well of course as the intermediate luminous spaces), from G to R, of which all beyond H are invisible. This picture is made by the use of lenses and prisms of quartz, as glass, even of the thinnest kind, entirely obstructs these rays. It was prepared as one of the illustrations for the new edition of Miller's Physics (the German copy) and may be there found.

In Becquerel's last book, just published, "La Lumiere," admirable copies of this photograph will be found in both volumes. It is engraved on steel, and being printed with a dark brown ink, is hardly distinguishable from the original.

The difficulty of producing such a photograph is very great, and certain imperfections seem as yet inseparable from the result. Thus,

as we have mentioned, all the apparatus through which the light passes is of quartz; but quartz is a double refracting medium; hence, even if we so cut the prisms and lenses from the crystal as to reduce the disturbance from this cause to a minimum, it will still exist and produce a notable effect.

Prof. William A. Miller, of London, made a very thorough investigation of the "photographic transparency of bodies," in the hope of finding something which could be substituted for quartz with advantage in this respect, but without success.

It is for the reason above noticed, we presume, that this actinic spectrum is deficient in the perfect definition of lines, which characterises the spectrum of the visible and actinic rays, produced by Mr. L. M. Rutherfurd, of which we have also a copy before us.

This photograph is forty-one and a half inches in length, and shows the part of the spectrum from the beginning of the blue (the green being absolutely devoid of photographic power, as has been demonstrated by Mr. Rutherfurd), up through indigo and violet to the limit of visibility, and of the rays which will traverse glass.

The sharpness of definition and fineness of lines in all parts of this spectrum is so great, that nothing more could be appreciated by the eye without the aid of a lens.

Comparing this with the German spectrum, we find that the space in the latter between the lines G and H measures about seven-eighths of an inch, and shows about thirty-one lines, while in that of Mr. Rutherfurd, it measures sixteen inches, and shows at least 600 lines. This greater expansion is of course due to the use of a greater number of prisms, but if attempted with those of quartz, would introduce such errors as to obliterate in all probability all the existing lines.

Tidal Rainfall.—In a recent communication to the American Philosophical Society, Mr. P. E. Chase discussed the rainfall of Philadelphia, with special reference to the position of the moon. His examination of forty-three and a half years' records at Pennsylvania Hospital, five years at Girard College, and seventeen years by Prof. Kirkpatrick, leads him to the conclusion that quadrature, apogee, south latitude and declination, horizontal attraction, and action in the minimum pressure-plane of the daily barometric ellipsoid, are each accompanied by a tendency to increase of rain and fall of barometer,—while syzygy, perigee, north latitude and declination, meridional attraction, and action in the plane of maximum pressure, tend to produce fair weather and a rise of barometer. He also finds that these tendencies, like the ocean tides, are more marked in low, than in high latitudes.

Civil and Mechanical Engineering.

THE ECONOMICAL CONSTRUCTION OF BEAM TRUSSES.

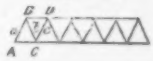
By G. S. Morison, C. E.

(Continued from page 287.)

Strains in the Chords (Bending Strains.)

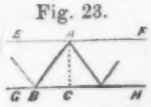
As the chords of a beam truss are at right angles to the direction in which the weight acts, the strains in them must be produced solely by the distributing action of the web, each member in turn producing its effect. Thus, in Fig. 22, the strut *a* imparts a strain to the lower chord at the point A, and to the upper chord at B, the tie *b* imparts a further strain at B and at C, the strut *c* at C and D, &c.

Fig. 22.



In Fig. 23, let E F and G H represent the two chords, and A B an inclined member of the web, B C being the amount of its inclination, and A C the depth of the truss. The strain in A B will be equal to the shearing strain at this point multiplied by A B and divided by A C, and the horizontal component of the forces acting in A B equal to the shearing strain multiplied by B C and divided by A C. This horizontal component is thrown entirely upon the chords, and hence the force applied to either chord by a member of the web is equal to the shearing strain at that point multiplied by the inclination of that member, and divided by the depth of the truss. While the shearing strain is positive, the forces thus thrown upon the upper chord act towards the right, and those thrown upon the lower chord, towards the left; when the shearing strains become negative, these directions are reversed. In each chord, the forces acting in opposite directions, balance one another; in the upper chord they act towards each other and create a compression which increases from each end to the point where the shearing strain changes its sign; in the lower chord they act from each other, and produce a tension of like intensity.

Fig. 23.

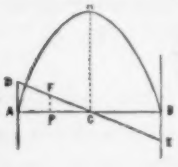


The strains in the chords increase at each point where an inclined member of the web terminates, but to simplify the investigation of the law of this increase, it may be considered gradual (as in a solid

beam), the inclination of the brace then disappearing as a factor in the rate of increase. The increment of the strain in the chords at each point is then equal to the shearing strain divided by the depth of truss; and the strain in the chords is everywhere equal to the sum of the shearing strains between that point and the end of the truss divided by the depth.

When a beam is uniformly loaded, the chord strains will increase with an uniformly decreasing increment from the end to the centre, and decrease similarly to the further end; the strains being everywhere proportional to the ordinates of a parabola. In Fig. 24, let D E be the line denoting the shearing strains in the uniformly loaded beam, A B. The chord strain at any point, P, is equal to the sum of the shearing strains between A and P, represented by the area of the trapezoid A D F P, divided by h, the depth of truss. Adopting the notation already used—

Fig. 24.



$$\text{A P} = \tfrac{1}{2}l - x,\ \text{A D} = \frac{wl}{2},\ \text{P F} = wx$$

$$\text{area A D F P} = \tfrac{1}{2}\left(\frac{wl}{2} + wx\right)\left(\tfrac{1}{2}l - x\right) = \frac{l^2 - 4x^2}{8}w$$

and the chord strains throughout the beam are the ordinates of the parabola whose equation is—

$$y = \frac{l^2 - 4x^2}{8h}w$$

When $x = \pm\tfrac{1}{2}l$, $y = o$, and when $x = o$ (centre of beam), $y = \dfrac{l^2 w}{8h}$

Making $\text{C H} = \dfrac{l^2 w}{8h}$, A H B, having its vertex at H, will be this parabola.

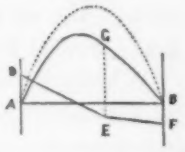
In the case of a beam partially loaded, the beam itself being supposed without weight, the chord strains in the loaded portion will be denoted by the ordinates of a parabola having its vertex over the point where the sign of the bearing strain changes, and in the unloaded portion by an inclined straight line (Fig. 25). As the curvature of the parabola, is determined by the inclination of the line D E, parallel to the line *de*, which denotes the shearing strain in the beam, A B, when uniformly loaded, this parabola has the same parameter as the parabola A O B which corresponds to the uniform load.

Fig. 25.

When a beam is loaded throughout, but more heavily in one part

than another, the chord strains will be denoted by parts of two parabolas, the parameters of which are determined by the intensities of the two loads (Fig. 26.)

Fig. 26.



A parabola passing through the points A and B, and having the central line C H for its axis, necessarily includes any similar parabola passing through either A or B, but having another line, as K O (Fig. 25), for its axis. This appears at once from the figures. It follows that the strains in the chords are everywhere greater when the beam is fully loaded than under any possible partial load, and an investigation of the effects of a full load includes all maximum strains. The same is shown by Plate 1, Fig. 11, where it is evident that the sum of the shearing strains between any point and one end of the beam is greatest when the whole beam is covered by the advancing load.

Reduction of the Strains in the Chords.

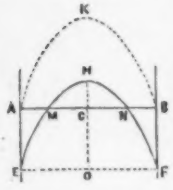
As the chord strains are inversely proportional to the depth of truss, the first step in reducing them is to increase this depth. Such an increase, however, is practicable only to a limited extent, a depth of more than one-eighth the length being seldom possible in long spans. The amount of material in the web increases but slightly with the depth (the entire increase being in the compression members) so long as the angular inclination of the braces remains unchanged, but when the depth is increased without changing this angle, the length of panel is also increased, and it becomes necessary either to sustain the road-way by independent trussing across the panels, or to increase the number of systems, thereby multiplying the details; either of which arrangements is more or less expensive and objectionable. But in a long span the chief limit to the depth is that imposed by the necessary requirements for stability against wind, which forbid the use of a depth too great in proportion to the breadth of base. The safe relative depth differs materially with the character of the bridge; it is greater in a through bridge than in a deck bridge, whose piers extend only to the bottom chord; greater still in a deck bridge, in which the piers are carried to the upper chord; while probably the arrangement which admits of the greatest depth is that in which the bridge is hung from points half way between the top and bottom, a plan adopted in the bridge at Mayence, across the Rhine, a double parabolic truss having a depth equal to more than three times the breadth of base.

In the cases of free beams already examined, the top chord is strained only in compression, and the bottom chord only in tension. If a tension could be imparted to the top chord, independently of the compression caused by the load, this tension would have to be overcome before any compression could exist; a like result would ensue if a similar independent compression were given to the bottom chord, the resulting strains in each case being at every point the difference between that caused by the load, and that existing independently of it.

The existence of tension in the upper chord, and compression in the lower, is the reverse of the effect of weight upon a free beam, and will tend to bend the beam in an opposite way. The two bending strains are properly distinguished by the use of opposite signs, the plus sign denoting compression above and tension below, and the minus sign the reverse.

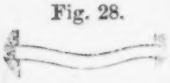
In Fig. 27, the beam A B is supposed to be subjected throughout to an uniform negative bending strain, equal to A E; if a load be now placed upon this beam which would produce in a free beam the positive bending strains denoted by the parabola A K B, the resulting strains will be given by the parabola, E H F. They will be positive between M and N, but negative from A to M, and from N to B; the strain at the centre is reduced from C K to C H, and the total amount of strains is represented by three small areas, A E M, M H N, and N B F, instead of by the large parabola, A K B. As in this case, the curvature is twice reversed, the bent beam will now resemble that shown in Fig. 28.

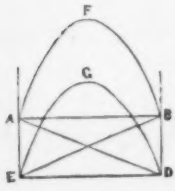
Fig. 27.



There are many obvious difficulties in the way of straining the chords independently of the action of the load, but if the ends of a beam were so secured as to be immovable, it is obvious that when the beam was loaded it would bend as shown in Fig. 28, and that as the effects are similar, the strains must be similar to those denoted by the resultant parabola, E H F (Fig. 27).* As in this case, the ends of the

Fig. 28.





* The load may be regarded as producing the usual positive strains, while the uniform negative strains are due to the reaction of the fastenings which hold the ends of the beam. The reaction of the fastening at A, produces the negative strains indicated by the triangle A B E, and that at A B, the negative strains denoted by B A D, the sum of the two being the rectangle, A B E D. Adding thereto the positive parabola, A F B, the resultant parabola, D G E, is obtained.

chords cannot move, the elongation in each chord due to tension would be exactly balanced by the opposite effect of compression, and the sum of the negative strains be equal in amount to the positive. Hence (Fig. 27), the areas—

$$\text{A M E} + \text{N B F} = \text{M H N}$$

or adding E M N F to both sides

$$\text{A B F E} = \text{E M H N F} = \text{A K B}$$

and substituting the value of these areas—

$$\text{A E} \times l = \tfrac{2}{3} l \times \frac{l^2 w}{8h} = \frac{l^2 w}{12h}$$

reducing we have—

$$\text{A E} = -\frac{l^2 w}{12h} \qquad \text{C H} = \text{C K} - \text{E A} = \frac{l^2 w}{24h}$$

The maximum strain is thus reduced to two-thirds the former amount, and the strain at the centre to one-third of what it was in a free beam. The equation of the parabola, E H F will be—

$$y = \frac{l^2 - 12x^2}{24h} w$$

which gives for M and N the points of reversal—

$$y = o \qquad x = \frac{l}{\sqrt{12}} = +\cdot 2887\, l$$

The total amount of the chord strain is reduced from—

$$\frac{l^2 w}{12h} \text{ to } \frac{l^2 w}{18h\sqrt{3}}$$

or to ·3849 of its former amount, a reduction of over sixty per cent. The saving of materials, however, in a truss with chords of variable section, will not quite equal this amount, as a considerable section of chord must be placed about the points of reversal, both to give continuity to the chords, and to provide against the variations caused by moving loads.

The strength of floor beams and door caps in buildings is greatly increased by building their ends into the walls, while every one knows how much the stiffness of a thin plank is increased by simply nailing down the ends; but in trusses of considerable length, it is difficult to take advantage of this source of economy. Sometimes it may be possible to anchor the ends of a wooden truss, as in the case of a deck bridge of a single span across a rocky chasm; a simple plan, however, is that adopted in a bridge over the little river Ciron, on the southern railway of France, a representation of

which is given in Figs. 29 and 30. This bridge, built to carry a double track railway, has a span of 98·43 feet in the clear, and is composed of three plate girders, the two outer ones being each 4·59 deep, and the intermediate one 6·56 feet. Fig. 29 is a general view of the bridge, while the details of the method by which the ends are made immovable, are shown in Fig. 30. The ends of the girders are formed with a square return downwards, and let into small apertures in the abutments (shown in elevation and in plan in Fig. 30); this return is fastened by bolts to the plate, *a a*, which bears against the face of the abutment. The effect of a weight upon the bridge, acting through the bent lever of the return, is to force the foot of the return towards the abutment, and confine the ends of the girder by the bearing of the plate against the masonry, the natural upward motion of the ends of the girder being thus ingeniously changed to a horizontal motion, which is more easily resisted.

Fig. 29.

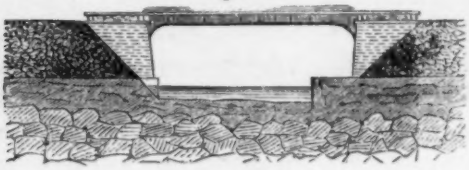
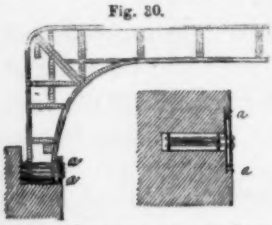


Fig. 30.



This bridge is remarkable for its lightness, and has been much admired, but there is no provision made for changes of temperature, and it cannot be regarded as a complete success. In fact, the difficulties which attend any method of fastening the ends of a truss become insuperable in metallic structures of large size, but in a bridge of several spans, much of the advantage of immovable ends with little of the disadvantage, is obtained by making the same truss continuous through the whole length of the bridge.

(To be continued.)

Water-Proof Paper, which may be used with excellent effect in packing goods which are likely to be exposed to damp or rain, may be prepared by treating strong unglazed paper with a mixture of equal parts copal varnish and linseed oil, with a little litharge to promote drying. The paper may either be painted alternately on either side with this mixture, or better, be immersed in a shallow pan containing it and drawn out over a wire stretched across near one end.

THE MISSISSIPPI BRIDGE.*

No engineering work at present in progress, either in Europe or in India, can pretend to exceed in interest the noble steel arched viaduct designed, and already commenced, by Mr. James B. Eads, the Chief Engineer of the Illinois and St. Louis Bridge Company. The able and exhaustive report which we have been enabled, through the courtesy of Mr. Eads, to lay before our readers will qualify them to form their own estimate of the difficulties to be surmounted; and the detailed engravings, which we shall shortly publish, will prove to them how carefully the various conflicting conditions have been balanced, and how conscientiously the several details have been worked out, so as to secure the highest practicable degree of economy consistent with the due stability of the works.

In the development of his design, Mr. Eads wisely commenced by making the stability of his piers indisputable. At the point of crossing, the true bed of the river, of limestone rock, is overlaid with a deposit of sand, varying in thickness from fifteen feet to about one hundred feet. There was ample evidence to prove that this deposit was scoured out to a great depth in times of flood, hence, to ensure the certain stability of the piers, but one course was open, namely, to carry them down to the rock itself. The ingenious method by which this is proposed to be accomplished will be found detailed in the report already published.

The massiveness of piers dictated by this condition, involving a height of some two hundred feet from base to summit, subject to the pressure of accumulated ice and great velocity of current, naturally suggested the adoption of an arched superstructure, since much less material would be required in such form of bridge than in any ordinary girder, whilst at the same time, in this instance, no extra expense would be incurred in the piers. At this stage, therefore, the problem resolved itself into the determination of the most economical form of arched superstructure.

In a long span-bridge, the weight of the structure itself is necessarily a large proportion of the gross load, and a very little consideration will show that from this condition it follows that to secure the highest degree of economy, it will be necessary to employ in the construction the strongest material available for the purpose The advantage thus gained is much greater than that indicated by

* *Engineering*, Sept. 25th.

the absolute strength of the several materials. Thus, if the strain due to the weight of the structure itself be two and a half tons per square inch, whilst the limiting strain is fixed at five tons, there will be only two and a half tons per square inch, available for carrying the useful load—that is to say, if we calculate the strain on any member, independently of the weight of the structure itself, we must divide by two and a half tons for the area in square inches. If, on the other hand, the limiting strain be twelve and a half tons per square inch, there will be ten tons per square inch available for the useful load, hence, the sectional areas will be one-fourth of the former amounts, although the material in the latter instance is only two and a half times as strong as before. The economy resulting from the employment of the stronger material would, of course, be still greater in cases when the strain from the structure itself is a greater proportion of the gross amount.

The first step taken by Mr. Eads was, therefore, to obtain the strongest steel for his work; and for the sake of economy, he proposes at present rolling his steel bars of a wedge form, and fitting them together in a nine-inch lap welded tube, by which they would be held together as the staves of a barrel are held by the hoops. This arrangement is, however, subject to modification, and should any deficiency of strength be exhibited in the tubes thus built up, when under test in the 1,500 ton machine now being built for that purpose, we may be sure they will not be introduced into the bridge itself.

Given the form of bridge, the load, and the material, a very important and laborious portion of the work, the determination of the sectional areas of the different members had to be entered upon. We are told by Mr. Eads that several months of patient labor were spent by Colonel Flad and Mr. Pfeifer, in the investigation of the various problems involved; and certainly the exhaustive nature of their report, which even in its compressed form fills some eighty pages with closely printed formulæ and computations, exclusive of numerous complicated diagrams, proves that no considerations of personal labor were allowed to interfere with the important work confided to them, of determining, with the highest attainable degree of mathematical accuracy, the requisite proportions of the several members of the Mississippi bridge. The final result deduced was to the effect that each arched rib, of which there are four in the width of the bridge, loaded each with one ton dead, and ·8 ton

rolling load, required a sectional area of 144 square inches between points about twenty feet from each abutment. For these twenty feet end pieces of the ribs, the sectional area required to be one-half greater, or 216 square inches.

We are enabled to test roughly these results of the rigid application of mathematical reasoning by applying the formulæ advanced in a paper on wrought iron arches and viaducts, by B. B., given in an early number of (*Engineering*, Vol. I., page 306.) We have the following data:—

W = total load distributed = 515 feet × 1·8 tons = 927 tons.

r = ratio of span to rise = 10.

d = " " to depth of rib = 64.

t = compressive strain per square inch = 12·5 tons.

w = ratio of total load to rolling load = 2·25 tons.

Then the area of the rib, if of uniform section, will never be less than $\frac{Wr}{8t}\sqrt{1+\frac{16}{r^2}} = 101$ square inches. With an arched rib fixed at the ends, as this one is, the preceding area will have to be multiplied by the factor $\frac{\frac{d}{5r}+\frac{3}{4}+w-1}{w} = 1{\cdot}47$ for the area at the springing, assuming the temperature to be constant; and for the area at the centre, under the same conditions, we may take the mean of the two already computed. Hence, at springing, the area would be $101 \times 1{\cdot}47 = 149$ square inches; and at centre $\frac{101+149}{2} = 125$ square inches.

The range of temperature in the case of the Mississippi bridge being more than double that assumed in the paper, from which these formulæ are extracted, the expression for the influence of temperature at the centre of the arched rib will become $\frac{t}{t-\frac{37r}{4d}} = 1{\cdot}14$. At the springing, the value will, as stated in the paper, be one and a quarter times that amount = 1·43. Hence, the final areas, to include all strains from changes of temperature as well as rolling loads, will be:

At centre, $125 \times 1{\cdot}14 = 143$ square inches.

At springing, $149 \times 1{\cdot}43 = 213$ square inches.

These areas are, curiously enough, in each instance little more

than a square inch below those deduced from the elaborate investigations of the American engineers.

In one respect, however, the Mississippi bridge differs essentially from the ordinary run of arched bridges, for which the preceding general formulæ was designed. Usually the spandril filling, even if arranged vertical only, possesses sufficient inherent stiffness, by virtue of the rigidity of its connections with the arched rib and horizontal girder, to assist materially in preventing any distortion of that member when under strain. In the instance of the Mississippi bridge the spandril verticals are positively hinged, so that not the slightest incidental support is afforded by them to the arched rib, the stability of which is, consequently, since there is no horizontal girder, governed entirely by the self-contained diagonal bracing.

In fact, the essential part of the bridge is a curved rectangular beam, eight feet by forty-four feet, the former dimension being the vertical depth of the bracing, and the other one the distance apart of the face ribs, which are firmly tied together by horizontal bracing. There can be no question as to the lateral stability of the structure, but the depth of vertical bracing is so small in comparison to the span—eight feet to five hundred and fifteen feet—that it is absolutely necessary to consider the question of stability in that direction. Now, there must obviously be some limit below which the depth of the arched rib could not be reduced, even if the load were always uniformly distributed, and the mathematical position of the centre of pressure corresponded with the centre line of the rib. Thus, if the rib were but six inches deep, it could no more maintain its form, for an instant, than it would if built of ropes. Why a depth of eight feet should be assumed, as it is in the calculations, to afford perfect immunity from all disturbing forces, we are at a loss to guess.

It appears to us that an arched rib, *per se*, is neither more nor less than a long column, and that it should, consequently, be treated as such. In a long column of uniform cross section, subject to two equal and opposite end forces acting at the centre of gravity of the cross section, the unit strain would, mathematically, be uniform throughout the entire column. Experiment proves, however, that in consequence of variations in the elasticity of the material, the strain is in reality very unequally distributed over the cross sections; so much so, that in columns of certain length positive ten-

sion is induced by a compressive force. Now, how it is that in calculations concerning arched ribs, or, in other words, curved columns, the unit strain should be assumed uniform if the mathematical position of the centre of pressure at any point corresponds with that of the centre of gravity of the cross section at the same point, whilst in a straight column, under similar conditions, it is shown by experiment to differ so widely from it, is not to us apparent.

In the Mississippi bridge, the least dimension of the column is about one-sixty-fourth of the length; but on account of the curvature of that member, it is in effect, to a certain extent, supported at the centre of its length; hence, the equivalent ratio will be greater than the preceding fraction. We have not investigated the question minutely, but theory appears to indicate that the equivalent ratio would be $\frac{1}{64} \times \sqrt{2} = \frac{1}{45}$th of the length. If this be so, the elastic resistance of the steel to be employed in the bridge should have been deduced from that of a bar forty-five inches long by one inch in diameter, instead of from that of a bar twelve inches long only, as appears to have been done. We know of no experiments on steel columns of the former ratio, except some recent ones by Kirkaldy, the results of which may not yet be published, but there are any number of experiments on similar wrought iron columns on record, and in no instance do we remember the breaking strain of either a solid or hollow column being greater than twelve and a half tons per square inch, or about one-half only the resistance a short column of the same material would offer. In a steel column the loss of resistance would probably be smaller in proportion, but it would unquestionably be far too serious in amount to be neglected in the computations of the strength of the Mississippi bridge. We do not mean to assert that, even if the maximum strain were twenty-five per cent. greater than stated in the report, the bridge would not still be perfectly safe and serviceable; but, at the same time, we cannot account for the omission of this important element in calculations so refined as those instituted for the determination of the strains on that structure.

We cannot endorse all the statements advanced in the report as to the superior economy of employing iron or steel in compression. In fact, if the reasoning were sound, it would follow that the resistance of a cylindrical boiler flue to collapse would be greater than its resistance to a bursting pressure. It is well known, however,

that even an approximation to this condition would, in practice, be attended with fatal results. The radius of the arched rib of the bridge we are considering is about eighty-four times its depth, so, within certain limits, it may be considered as placed under similar conditions to a cylindrical flue, seven feet diameter, constructed of half inch steel plates, and subject to external pressure. The increased resistance which such a tube would offer, if properly stiffened by diaphragms, is well known to practical men, and precisely analogous support would be afforded to the arched rib if the spandrils were properly braced. Neglecting the element of the long column, the present arrangements would probably be the most economical; but if we include that in the consideration, it will be found that the increased strains from expansion, contraction, and deflection, due to the bracing of the spandrils, will be more than counterbalanced by the increased resistance the arched rib could offer to compressive strains, whilst, at the same time, the structure would be far less liable to vibration.

We have criticised thus freely the design for the Mississippi bridge, because we are sure that its originators have nothing to fear, and desire nothing more than a perfect ventilation of the subject. The entire process of reasoning by which their conclusions have been arrived at has been laid by them before their European brethren, whose criticism is thus boldly challenged. So much talent and perseverance has been already evinced that we are confident no one could hope to find the carrying out of this important work in more able hands. We still think that a somewhat cheaper and more easily erected bridge might be designed on the cantilever and central girder system, known as Sedley's; but, at the same time, no one can doubt that the structure, as designed, would form one of the noblest monuments of the engineering skill of the nineteenth century.

PERMANENT WAY.

ALTHOUGH the Permanent Way Company—of which nothing, we believe, has been heard since the death of Mr. Charles May, in 1860—was often disparaged as a jobbing speculation of railway engineers, it really did do something for the good of the so-called permanent way itself. This company—a very limited company in

* *Engineering*, Oct. 2d.

point of numbers—knew how to exercise a powerful agency for agitation in the right quarters; it greatly promoted the general adoption of the fish-joint, and it greatly stimulated that kind of permanent way scheming, called "invention," both among the company's own shareholders and among envious outsiders, ambitious of the possession of profitable patents of their own. *Requiescat in pace.*

The importance of a further improvement of the permanent way of railways is too great and too apparent to be disputed. It cannot, perhaps, be effected by a "company" of engineers or others—possibly not even by the powerful aid of profitable patents. We are not sure whether there is such a thing as patent earthworks, patent drainage, and patent ballasting. Whatever the way may be, its bed must be upon mother earth, and as our engineers make this bed so must lie their works. Cannot somebody patent something, and thus be able to push his invention, which shall prevent this bed from becoming so quickly tumbled under the unquiet rest of the seven sleepers (to each length of rail), sleepers whose rest should be lifelong, despite the thundering of expresses, mails, "ordinaries," "ways," goods, and minerals, over their much enduring necks and shins? Patent or no patent, our permanent way must have better bed and bedding, neither saturated with water nor pulverulent in dust; a bed like the operating table of an hospital, where all motion is well nigh impossible.

> Oh, bed! bed! bed! delicious bed!
> That heaven upon earth to the weary head,
> Whether lofty or low its condition!

and whether the weary-headed rail be of steel or iron, double or single-headed, or $5\frac{1}{2}$ in. or $3\frac{3}{4}$ in. "in condition" of loftiness or abasement.

Until we have much better earthworks, which, like the foundations of a house, can lie still and support in perfect rest almost any load brought upon them, we can never have mathematically perfect railways, and until we have these we must tolerate that needless and extravagant increase of resistances which attends any increase of speed above the lowest rate of motion—an increase from 10 lb. or so per ton at very slow speeds on a level, to 30 lb. or 40 lb. at 60 miles an hour. It is idle to say that we can have no better earthworks than we now have, or that the permanent way can rest no

more quietly than it now does even on the best earthworks. The great bed of *wear* (and of *tear* as well) should be, and might be, almost as smooth as a billiard table, or at any rate as smooth as the best macadam roads in the days when stage coaching was in its superlative glory.

With the best earthwork and ballasting there must be abundant bearing surface of the rails on the sleepers, and of the sleepers on the ballast. Every permanent way engineer knows that the bearing surface is now insufficient to prevent the rails from notching upon the chairs, the chairs from bedding themselves in the sleepers—sometimes half way through—and the sleepers from churning the ballast. Mr. Fowler has long since abandoned the double headed rail, with its costly accessories of chairs, keys, and treenails, and adopted a Vignoles rail with a base nearly 6½ in. wide, which is fastened to the sleepers by screw bolts. Nothing but a rail of such proportions would ever stand the tremendous wear of the Metropolitan Railway traffic, and nothing but flat-footed rails, with bottom flanges as wide as can be rolled, say, up to 9 in., supported on sleepers a foot wide, 8 in. thick, and only 2 feet 3 in. apart centres, will suffice for the heaviest traffic soon likely to come upon our first-class railways. Thicker sleepers will permit the use of longer sleepers, without losing the available bearing now lost in consequence of the springing of sleepers only 5 in. thick. Sleepers 9 ft. long, 10 in. wide, and 3 ft. apart centres, give 13,200 square feet of bearing upon the ballast in a mile of single way. Sleepers 10 ft. long, 12 in. wide, and 2 ft. 3 in. apart centres, would give 23,466 square feet, or nearly twice as much. This width and closeness of sleepers would not prevent the proper packing of the ballast, and it would permit of the use of engines of from 50 tons to 75 tons weight—engines which must yet become general, not so much because of the probable increase of traffic as from the greater economy of heavy engines where the permanent way is such as to bear their weight. On land and in steamships there is no limit to the size of engines, merely because the foundations are good; and were the foundations of the permanent way what they ought to be, and were its own structure correspondingly strong, there is no reason why 100 ton locomotives should not become as common as were 10 ton engines in the days of George Stephenson's earlier practice.

But without steel rails there could have been no great improvement in the construction of permanent way. Had they been the

subject of a patent, not of a "non-professional," or, in other words, of a non-railway, man, but owned by a permanent way company of the character of that of fifteen years ago—"good lord!" as Captain Cuttle observed of Sol Gill's suppositious clock, "how that rail would go!" As it is, railway companies have bought (or made), and laid down a few hundred tons of it, almost upon compulsion, or, in other words, because they could not well do without it, grumbling, meanwhile, through their officers, that a rail from five to ten times as good as iron could not be supplied at the same money. There are many high minded railway engineers upon whom we would on no account cast the least word of aspersion, but there are other engineers, too well known, who will "take up" nothing out of which they can make nothing—gentlemen whose sole motto would appear to be *ex nihilo nihil fit*, unless it be in plain English, "palm oil." But like the steam engine, the spinning mill, the hot blast, the locomotive engine, ocean steam navigation, the electric telegraph, and submarine telegraphs, the steel rail had its seven years of probation, and it came out of them well. It has proved itself to be incomparably safer than iron; from five to twenty-five times as durable; to make a better and smoother way, offering less resistance to traction, and to permit of the use of still heavier engines, the very heaviest locomotives which the permanent way will bear without undue injury or wear, being always the most economical. The steel rail has done, to a considerable extent, for the permanent way what the steel tyre has done for the rolling stock, and on all very hard worked lines, such as the railways in and surrounding London, both are indispensable. The Metropolitan and North London railways could now hardly be worked at all with iron rails and tyres, of however good quality. "Converted" iron rails, or rails case-hardened at the top by Dodd's process, steel-headed rails and "puddled steel" rails, the latter a variable and irregular compound of cast and wrought iron, have been put to the test and failed, until now steel and steel only is tolerated. And yet we have engineers at work, figuring equations in compound interest upon the cost of iron and steel rails respectively, as if the latter had nothing but their greater durability to recommend them, engineers to whom all rails would appear to be equally safe, all rails, of whatever material, equally smooth and stiff in respect of the resistances to traction, and engineers, who recommend waiting for another year, until the steel rail patent has expired, well knowing

that with the growing improvement in trade, the increasing competition for hematic iron, Durham coke and spiegelesein—these being the elements of the steel rail manufacture—and that with the heavy demand which must soon arise for steel rails, wherever railroads are, their price is certain to increase by more than any possible diminution due to the removal of the royalty. In France and America all the great lines are being rapidly laid in steel, not only on the score of economy, but as a safeguard against the accidents which were constantly happening, and which occasionally happen here from the breaking of iron rails.

Railway engineers and railway companies must and will learn that upon the perfection of the way depends the highest working economy. After expending millions in Parliamentary struggles, millions for compensation, millions upon earthworks, colossal bridges and viaducts, tunnels by the mile, stations of the grandest dimensions and of superb architecture, and millions for costly locomotive and carriage stock, the question of a few thousand pounds more or less per mile for first-class permanent way is not one upon which true economy in working and in maintenance can be sacrificed. There are railways enough which have cost their £100,000 or more per mile, and plenty that have cost £50,000, whereas the difference between the cost of a really good as compared with an ordinary permanent way—the platform upon which all the functions of a railway are really discharged—need not exceed £3000 per mile.

BELTING FACTS AND FIGURES NO. II.

By J. H. Cooper.

(Continued from page 244)

Tensile Strength of Belts.

"From various experiments, the absolute strength of ordinary belting leather is found to be 3860 pounds to the square inch of cross-section"—*Sci. Amer.*, February, 1860. 84.

R. G. Carlyle, in *Sci. Amer.*, July 1866, p. 35, gives the following results of actual experiments made by him: "Mean breaking tensile strain of five experiments with leather belts, $\frac{3}{16}$-inch thick, and 1 inch wide, 552 pounds. Reduced to $\frac{3}{4}$-inch wide at place of rupture."

Mean of five experiments with leather belts $\frac{3}{16}$-inch thick and 2 inches wide, 1077 pounds. Reduced to $1\frac{5}{8}$ inch wide at place of rupture. Fracture commencing at the edges.

Mean of three experiments with leather belts $\frac{3}{16}$ inch × 3 inch, 1522 pounds. Reduced to $2\frac{3}{4}$ inches wide at place of rupture.

Mean of all per square inch of section, 2846·4 pounds.

"Mean breaking strain, five experiments, of 'three-ply' cotton-filled rubber-belts, 2 inches wide, 1211 pounds. Did not contract perceptibly, and broke all at once, emitting a perceptible smell of rubber."

Mean of five experiments with 3-inch rubber belting, 1763 pounds.

"Experiments in great number were made with lacing, of various widths and thicknesses, but the result varied so much—no two being at all alike—and very much appeared to depend on the part of the skin from which the thong was cut. For instance, in some cases, a thong from near the back bone had four times the strength of that from other parts, so I could get no data that was worth noting."

"The next experiments were made to determine the weakening effect of punching belts for the lacing, and the results proved that the belt was weakened to the extent of the sum of the diameters of the holes, if they were in a straight line across the belt."

"The diagram here given will show the position of the holes in the belt which gave the very best results, as its cross-section is only weakened by two holes in any place. A B was not cut, and C D was the invariable line of fracture, which first began at the edges, found assistance at the nearest holes to the edges, and continued across on the same line."

"From these trials, it can be seen that oval punches would be much superior to any other, as they would cut away less of the cross-section of the belt, and still give ample space for the lacing."

"The next experiments were made with belts punched as in the above diagram, but cut through the line A B, and then laced in a secure manner, results as follows: "In leather belts, tearing began at the holes at $\frac{5}{8}$ths of the breaking strain, and continued on until the lacing tore out at the end holes, when the rest went suddenly."

"In leather belts, after being subjected to one-half of the breaking strain for twenty-four hours, a slight addition to the weight caused

them to tear at the holes, which, after commencing, proceeded rapidly, until the end holes tore out, when it went as before. After being subjected to one-half of the breaking strain for forty-five hours, it went as before stated. They stood one-third of the breaking strain for one week, and at the end of that time showed no signs of fracture."

"In rubber-belts, tearing began at one-third of the breaking strain. They stood one-fourth for twenty-four hours, but tore on a slight addition of weight. They stood one-eighth for one week, without showing any signs of fracture. Eyeletting the holes brought the standing point up to that of leather belting, the clinching of the eyelets on the cotton fibre or filling reducing the tendency to tear. I think that large oval eyelets would materially improve the fastening of such belts, particularly if the eyelets had large flanches so as to grasp or confine the material. They also operate well with leather belting, as their action is to distribute the strain all round the circumference of their holes, which is not the case without them, only a portion of the hole then receiving the strain. They likewise take from the belt the rubbing action of the lacing in rendering through the holes, which must have some effect on the portions in contact, as no belt can be laced so that the lacing will not render to some extent, saying nothing about the action of the same in the passage over pulleys, especially those of small diameter, where the action is continuous while in use transmitting power. My experiments with eyelets were not as satisfactory to me as I could have wished, as I was unable to carry them to any great extent; after so favorable results, on account of not being able to get them sufficiently large to take the lacing. I am confident that if I could have got them large enough and of oval shape, that I could have tested the belts up to very near their breaking strain, I think that eyelets made expressly for the purpose would materially increase the duration of belting."

"I lately made a series of experiments to ascertain facts governing the transmission of power by pulleys with belts." The apparatus consisted of pulleys of different sizes fixed in position with axes horizontal.

The pulleys used were of cast iron, having slightly rounded and smoothly turned faces; over the pulleys different belts were laid, and to the pendent ends certain weights were hung.

"The trials were to be certain weights put on the ends of certain

sized belts, when a preponderance would be put on one side until a perceptible motion occurred, when the whole was noted."

"The following table will give the facts as they were taken:—

TABLE "A."

Diameter of Pulley.	Kind of Belt tried.	Thickness of Belt.	Width of Belt.	Weight on Platform, including Platform and parts.	Weight on Hook, including Hook	Tension of Belt.	Amount of Adhesion.	Proportion existing between Tension and Adhesion.	Remarks. * doubtful.
Ins.	Lea.	Ins.	Ins.	lbs.	lbs.	lbs.	lbs.		
12	"	$\frac{3}{16}$	1	150	50	200	100	2 : 1	Same belt in each case, old but good.
24	"	"	1	150	50	200	100	2 : 1	
12	"	"	2	151	50	201	101	2 : 1	Old lathe belt, sticky.
12	"	"	2	300	100	400	200	2 : 1	Old belt in good order.
24	"	"	2	150	50	200	100	2 : 1	" " "
12	"	"	3	150	50	200	100	2 : 1	" " "
24	"	"	3	300	100	406	206	2 : 1	*" " "
12	Rub.	3-Ply	2	190	50	240	140	12 : 7	" " "
24	"	"	2	369	100	469	269	23 : 13	" " "
36	"	"	4	372	100	472	272	59 : 34	" " "

"The deductions to be made from the above results are, that the adhesion of any belt on a pulley is directly as the tension, and not as the surface in contact, for the same results invariably attended the same tension, whether the belt was double the width, or the pulley double the diameter, or both."

Rubber belting adhered better than leather with the same tension; this was particularly the case when belting, which was worn and glazed somewhat on the bearing side by use, was tried.

New belting did not give good results, and a great deal seemed to depend on the condition of the belt tried. This was not so much the case with leather belting, which was more uniform in the results; new belting gave very near the same result as old belting "not gummed up," for the more it was gummed the better was the adhesion. * * * * * * *

"From my experiments I made up certain rules for practice in all cases, as I was able to bring the elements down to a fixed basis. Since doing so, I have never made a single failure, besides being able to increase the durability of the parts liable to wear, by really knowing what they were subjected to, and what could be demanded of them."

"The following are my rules and practice:—

"I always put the side of the belt which transmits the power on the bottom, when the power is given out horizontally; in that position, the slack side is where it should be—on the top; where the tightener—if one is used—should be. If power is transmitted vertically, I always put a swinging tightener on the slack side, which operates by falling towards a horizontal position."

"I submit belts to 50 pounds per inch of width, of tension, which is made up of the power to be transmitted and their own weight. Where the distance between centers of pulleys give sufficient tension, no tighteners are used. Where they are too close together, I use tighteners—no curve on their face—of as large diameter as is convenient. I count on getting 20 pounds of adhesion from 50 pounds of tension in all cases."

"I count the power to be transmitted as so many pounds at the end of a lever, of the length of the radius of the pulley—the velocity being in the calculation by which the number of pounds were got—and divide the number of pounds by 20, the adhesion, for the width of the belt in inches. I then see if the distance between centers will give the necessary tension to make the first calculation good, if not, the remedy is a tightener, if the distance cannot be increased. If the width of belt got by these means is too great, then the diameter of the pulley—or the radius, which is the same—must be increased; by doing so, the number of pounds to be transmitted at the end of the lever is diminished, I again divide by 20; and if the width is again too great, I again increase the lever until I get it down to what I want it; and the whole proceeding is as certain as it is simple."—R. G. C. in *Sci. Amer.*, July, 1866, p. 51.

Tensile strength of Calves' skin.....					1890	pounds	per	square inch.
"	"	Sheep	"	(Brazil)	1610	"	"	"
"	"	Horse	"	(White)	4000	"	"	"
"	"	"	"	(Russ.)	3200	"	"	"
"	"	"	"	(Cord.)	1680	"	"	"
"	"	Cow	"	.....	3981	"	"	"

Lond. Mech. Mag. March, 1863.

Material.

"There is nothing like leather for straps."

"In regard to purchasing belting, I believe that the best white oak tanned leather will be found 50 per cent. the cheapest in the end, and my mode of preparing a new belt is to soak it for about ten minutes in water, then let it dry fifteen minutes, then brush it over two or three times with neat's foot oil. When it is well dried, I put on the belt, and oil it once in two months in cold weather, and once a month in warm."—P. in *Sci. Amer.*, March, 1860, p. 150.

Treatment of Leather for Belts.

"I stuff my belts with a composition of two pounds of tallow, one pound of bag-berry tallow, and one pound of beeswax, heated to the boiling point, and applied directly to both sides by a brush, after which the belts are held close to a red-hot plate to soak the beeswax in, which does not enter the pores of the leather from the brush."

"Care must be taken to have the leather perfectly dry to prevent burning. I placed a kettle of the composition over a black smith's fire, and after melting it, I put in a coil of two-inch belting about sixteen feet long, and boiled it forty-five minutes in the greatest degree of heat I could produce by blowing the fire continually, and the belt when taken out was not in the least injured by the heat of the composition. I then tried a piece of belting damped with water, and found it burnt and crisped in less than half a minute."

"The application of neat's foot oil to belts, opens the pores of the leather and destroys the adhesion of its parts, and in a very short time renders it flaccid and rotten, and a belt will not last half so long stuffed with oil as with the composition above named. Belts stuffed with the composition are impervious to water, and will run well for six months."—J. H. B. *Frank. Ins. Jour.*, June 1837, p. 457.

To keep leather belts in good condition, I have never found anything equal to fish oil mixed with the spent grease of journal box-pans."—C. G. in *Sci. Amer.*, April, 1859.

"When a belt gets harsh or dry, neat's foot oil is the best thing to apply to it."—*Sci. Amer.*, January 1868, p. 55.

"Use neat's foot oil once a week, will give regular speed, and last double the time. Experience has established the correctness of placing the smooth side of the belt next the drum or pulley."—H. M. in *Sci. Amer.*, June, 1848, p. 326.

Condition of Belts.

"Soft and pliable belts have three times the adhesiveness of those made from the same leather, but which are hard and stiff."

"It is generally reckoned that from 1 to 2·2 per cent. of the power communicated is lost by the stiffness of a leather belt."

Slipping Tendency.

Three pulleys were fixed on an immovable shaft; one was a smooth iron pulley, like those in common use, one was covered with leather, and one with gum. A 3-inch leather belt about 7 feet long, was thrown over the iron pulley with thirty-two pounds on each end to give adhesion. It was found by experiment that forty-eight pounds additional on one side were required to produce slippage. Sixty-four pounds additional when on the leather-covered pulley, and 128 pounds additional when on the gum-covered pulley.

A 3-inch vulcanized belt under similar treatment, gave the following result: 90 pounds on the iron pulley, 128 on the leather, and 183 on the rubber.

For record of experiments, see *Sci. Amer.*, March, 1859, 216.

This record is unfortunate, in not giving the diameter of pulleys, nor the condition of the several belts used. The leather belt is spoken of as being of "good quality," but there is a vast difference between simply the quality of the leather and the condition of a belt with reference to its tendency to slip.

It is not adhesion alone we want to prove the better belt; beyond a certain amount it is rather an injury to the belt than an advantage in its use; for slippage is to be preferred to abrasion, when rapid destruction of the belt would result from the closeness of its striking; an infirmity to which rubber belts are liable.

(To be continued.)

Mechanics, Physics, and Chemistry.

THE SUGAR INSECT—ACARUS SACCHARI—FOUND IN RAW SUGAR.

By Robert Niccol, Esq.*

Raw sugar should never be used for dietetic or domestic purposes; because it contains organic impurities; and more especially immense numbers of disgusting-looking insects, termed the "Sugar Insect"—found to be invariably present in *raw* or *unrefined* sugar. This insect is known by scientific men as the *Acarus Sacchari;* and when seen by the aid of a microscope, is found very much to resemble the sea-crab in its appearance.—See the accompanying engraving, which represents the insect as magnified to about 200 diameters.

No one, indeed, who has seen the filth and gross impurities extracted from the raw sugar in a refinery, could ever after use anything but the refined article. Pure sugar is, indeed, almost as desirable an article of food as pure water; and all should be anxious to substitute the *refined* for the *raw* material. Bad water and raw sugar abound in animalcules and vegetable impurities; but pure water and refined sugar are free from such. There are many grocers who sell raw sugar under the notion that it is more economical to their customers than the refined article; and the latter parties (unaware of anything to the contrary) readily purchase the commodity under this impression. This is, however, a great mistake, which requires to be at once corrected. The finest qualities of *raw* sugar do invariably contain very gross impurities; but the cheapest kind of *refined* sugar is perfectly pure and wholesome in every respect; and it can be obtained at the grocer's shop at as reasonable a price as the raw material—the refined article being invariably found to be genuine, in so far at least as its purity and wholesome qualities are concerned. This, let it be observed, is no mere haphazard assertion; for it is founded on fact: and the writer submits the following in proof of what he now states.

The following are extracts from a pamphlet on the subject by Professor Cameron, of Dublin:—

* From an Essay on Sugar and Sugar Refining. Edinburgh: Published by Williams & Norgate.

"In my capacity of public analyst for the city of Dublin, I have had occasion to examine, more or less minutely, nearly one hundred and fifty specimens of sugar, in quality varying from the purest white to the darkest brown. The greater number of these samples were perfectly genuine: some were of rather indifferent quality: and the rest—about fifteen—were so impure as to be quite unfit for use: they abounded in organic filth, and contained great numbers of disgusting insects. All the samples of very inferior sugar were of the kind known as raw; and in no instance did I detect in the refined article the slightest trace of any substance injurious to the health or repugnant to the feelings. With such facts as these before me, and writing in the interest of the consumer, I advocate the exclusive use of refined sugar. I unhesitatingly assert that no one who pays any attention to the purity of his food, aware of the nature of the impurities so frequently abounding in the raw article, could, without a feeling of loathing, make use of it. If, then, the exclusive use of sugar be a desideratum, it is not less desirable that those who are engaged in the manufacture of that article should receive due encouragement, consistent, of course, with the principles of free trade, from the governing bodies. But it will hardly be credited by those not well informed on the subject of our national finances, that the present method of levying the duty upon sugar is *needlessly* inimical to the British refiner. It is so arranged that it obliges the planter to attempt, under the most adverse conditions, the refinement of sugar: it compels the British refiner to purchase the semi-purified article, and to undo all that the colonial refiner had done; and, finally, it makes the low class sugar consumed by the poorer classes pay more duty, in proportion to the pure sugar present, than the superior article which is purchased by the middle and upper classes. The use of raw sugar is rapidly on the decline, and I venture to hope that the publication of this little treatise will aid to utterly extinguish it. Should its pages be glanced over by any influential member of the Legislature, I trust it may be the means of inducing him to turn his attention to the present anomalous method of levying the sugar duty, with a view to its early reformation.

"The insects found in sugar are Beetles and *Acari*, or mites. The beetles, which are more familiarly known to the sugar dealers than to the general public, may frequently be seen running nimbly along the tables in the sugar warerooms. The *Acari* are minute insects, and do not attract attention. There are several kinds of *Acari*: the

cheese mite, the insect found in partially decomposed flour, and the minute parasite, which, by burrowing beneath the skin, produces the disease termed the itch—are all different varieties of *Acari*. The mite found in raw sugar is termed the *Acarus sacchari*, or Sugar Insect: its shape is very accurately shown in the accompanying engravings—Fig. 1 representing the under side, and Fig. 2 the upper side of the insect.*

"The *Acarus sacchari* is a formidably organized, exceedingly lively, and decidedly ugly, little animal. From its oval-shaped body, stretches forth a proboscis terminating in a kind of scissors, with which it seizes upon its food. Its organs of locomotion consist of eight legs, each jointed and furnished at its extremity with a hook. In the sugar its movements from one place to another are necessarily very slow, but when placed on a perfectly clean and dry surface it moves along with great rapidity. It has been stated that the *Acarus scabiei*, or itch insect, possesses the power of leaping, but all my attempts to induce the *Acarus sacchari* to make a jump failed, although it was placed in the most favorable positions for the performance of such a feat.

"The disease termed *psora*, or *scabies* by medical men, but more popularly known by the expressive designation of the 'itch,' is, I venture to hope, only known by name to my readers. It is, I admit, not a nice theme to discourse upon, more especially in connection with such a subject as sugar; but as this malady and its cause are intimately connected with my objection to the use of raw sugar as food, I cannot avoid—even at the risk of offending the sensibilities of some of my readers—alluding to them. So early as the twelfth century, an Arabian physician, named Abinzoar, observed that a skin disease was produced by the ravages of little insects. They burrowed, he says, beneath the skin of the hands, legs and feet, and produced pustles, containing fluid. From the description of these insects given by Abinzoar, it is quite evident that they were not 'little lice,' as he terms them, but a species of mite, or *Acarus*. The same kind of insect was noticed some centuries afterwards by many distinguished physicians and naturalists, one of whom, named Bonomo, described it by the aid of a drawing, in the year 1683. The itch, then, is proved to be produced by this *Acarus* making

* For this engraving of the sugar insect the author is much indebted to Alfred Fryer, Esq., of the well-known firm of Fryer, Benson & Forster, sugar refiners, Manchester.

burrows beneath the skin, and depositing therein its eggs; and hence the insect has been named the *Acarus scabiei*, or scab mite. Mange in horses, cattle and dogs, and scab in sheep, are essentially the same disease as itch in man. As a general rule the persons most liable to be preyed upon by the *Acarus scabiei* belong to the lower classes—in fact, are members of the 'great unwashed' family: the disease is very rare amongst the middle and upper ranks, and, indeed, wherever the abundant use of soap and of clean linen prevails. Now, it is a note-worthy fact, that grocers' assistants and sugar warehouse-men are peculiarly liable to a kind of itch which affects their hands and wrists, but does not extend to any other part. These persons are usually of cleanly habits, and do not belong to the classes amongst whom the ordinary itch is so prevalent; there is, therefore, but one way of accounting for their tendency to contract that disease—namely, that the *Acarus sacchari*, having, like its congener, the *Acarus scabiei*, burrowing propensities, bores into their skin, and breeds there. The two kinds of *Acari* resemble each other very closely,* but the sugar insect appears to be the larger and more formidable. So common is this pustulous disease amongst persons engaged in the 'handling' (*i. e.* mixing) of sugar, that it has been termed the 'grocer's itch;' but I doubt very much that it differs in any specific respect from the ordinary variety of that nasty complaint. My colleague, Dr. Symes, surgeon to Dr. Steevens' Hospital, assures me that persons suffering from 'grocer's itch' are always to be found amongst the extern patients treated at that institution.

The number of *Acari* found in raw sugar is sometimes exceedingly great, and in no instance is the article quite free from either the insects or their ova (eggs). Dr. Hassall (who was the first to notice their general occurrence in the raw sugar sold in London,) found them in a living state in no fewer than 69 out of 72 samples. He did not detect them in a single specimen of refined sugar. The results of my examination of the sugar sold in Dublin coincided pretty closely with Dr. Hassall's experience. In the refined sorts, I found nothing but crystalizable and non-crystalizable sugar, and a little saline matter; in the raw kinds, organic and mineral filth—often in great abundance. One of the samples which I examined, contained a larger number of insects than I believe had previously been noticed, or at least recorded, by any other observer. It was

* By some authorities they are considered to be identical.

sent to me, together with other articles, in May last (1863), by Mr. Horner, the master of the South Dublin Union Workhouse, and the following is the report which I made upon it: I have rarely examined a more inferior sample of sugar; it is extremely damp, contains a very large proportion of treacle, and a considerable amount of such impurities as sporules of a fungus, particles of cane, albumen, and starch granules. These substances, however, though greatly detracting from the value of the sugar, are not injurious to health. I cannot say as much for another impurity which exists in great abundance in this sample—namely, a species of *Acarus*, closely resembling in appearance and nature the insect which, by burrowing into the skin, produces the itch. It is no exaggeration to affirm that there cannot be less than 100,000 of these insects in every pound of this sugar. In ten grains weight, I estimated no fewer than 500, most of which were so large as to be distinctly visible to the naked eye. It is inconceivable that thousands of these creatures can be introduced into the stomach of a human being without serious endangerment to health. But not only is such sugar as this sample detrimental to health, it is also the least economical kind which can be employed. It greatly impairs the flavor of tea and coffee; and its high proportion of water and other useless ingredients lowers its sweetening power to an extent which even its low price fails to compensate for. Many persons believe that coarse brown sugar sweetens better, or, to use the common phrase, 'goes farther' than white sugar; but that is a mistake. A tea-spoonful of damp brown sugar will certainly sweeten a larger quantity of fluid than a spoonful of white sugar; but it does so because it is much heavier than the latter; but if equal weights be used it will be found that the white variety is by far the better sweetener. *The kind of sugar which is both healthful and economical is the dry, large grained, and light colored variety.* If you cannot obtain such an article, you should purchase the lightest brown kind; and bear in mind that such sugar as I have examined for you is the most inimical to health, and the least value for your money which you could possibly get.

"The publication of the foregoing report in the newspapers excited considerable interest in the public mind; for, excepting a few scientific men, no one in Dublin appeared to have been previously aware of the existence of the *Acarus sacchari*. The assertion that one pound weight of raw sugar contained a hundred

thousand active insects, must, no doubt, have appeared incredible to some people; but that I was not guilty of exaggerating the number was proved by the results of subsequent examinations made by other observers. A committee of microscopists, composed of Drs. Aldridge, Minchin, Symes and Booth, and Mr. Reynolds, visited the workhouse, and, in the presence of its officials, examined the sugar and satisfied themselves that my account of it was, in every respect, an accurate one. Two samples of the sugar were also examined, one by Dr. John Barker, Curator of the Royal College of Surgeons, Ireland, the other by Dr. Hassall, of London, a very eminent authority upon the subject. In fifteen grains weight, Dr. Hassall found considerably over 100 living insects, or at the rate of 42,000 per pound; and Dr. Barker estimated no fewer than 1,400 in forty-five grains weight, or at the rate of 268,000 *Acari* in each pound weight of sugar.

"With the exception of the date sugar made in the East,* every kind of raw sugar contains *Acari*. They are least numerous in the very damp, treacley kinds, because, as they are air-breathing animals, they cannot exist in treacle or water. If a spoonful of raw sugar be dissolved in a wine-glass full of water, the animalcules will speedily come to the surface, from which they may be skimmed off and transferred to the object-glass of the microscope. On the surface of the water they appear as white specks, and as they swim about vigorously, their movements are quite apparent to the naked eye.

"The *Acari sacchari* do not occur in refined sugar of any quality for the following reasons:—Firstly, because they cannot pass through the charcoal filters of the refinery; secondly, because refined sugar does not contain any nitrogenous substance (such as albumen) upon which they could feed—and I have already shown that even the most insignificant animals cannot subsist solely upon sugar, or upon any other kind of food destitute of nitrogen. The only impurity found, and that rarely, in refined sugar, is a trace of iron; its origin is easily explained: At the refinery, the sugar, after its solution in water has been effected, is sometimes put into iron cisterns, where it remains until filters are ready for its reception. If, through negligence, the solution is allowed to remain too long in contact with the iron, it is certain to dissolve a minute portion of the metal, from which its subsequent treatment fails to

* The date sugar, which is free from *Acari*, is practically a refined kind; its crystals having been repeatedly "clayed," or washed with water.

entirely separate it. When iron in solution is brought into contact with the body termed *tannic acid*, the two combine and form a black substance, which is the basis of most kinds of black ink. Tannic acid is a natural ingredient of tea; if, therefore, sugar containing iron be dissolved in an infusion of tea, the fluid will instantly acquire an inky hue. The presence of a small quantity of iron in sugar does not in the slightest degree injure its nutritive or healthful qualities; still as tea resembling ink in *appearance*, however agreeable to the palate, would be displeasing to the eye, sugar which would thus affect its color is unfitted for domestic use.

"Would any one, with the slightest pretension to cleanly notions, drink stagnant water if he could as easily obtain the element pure and sparkling from the fountain? May I not add, is there any one so indifferent as to the purity of his food, who would consume raw sugar, *knowing* it to be teeming with disgusting forms of animal life, if the pure article were as readily obtainable? The sanitary reformers have clearly proved that the health of a community is, to a great extent, dependent upon the quality of the water they drink; and the public at large accept the results of the philosopher's reasoning. At the present moment the citizens of Dublin are heavily increasing their already ponderous load of taxation for the purpose of obtaining an abundant supply of pure water. The water which the citizens of Dublin at present use is considered unwholesome, because it contains low forms of vegetable life, and abounds in animalcules; and these are just the kinds of impurities which exist—but in immensely greater quantities—in raw sugar. Is it not, therefore, but rational that if we substitute the pellucid water of the Vartry for the stagnant fluid of the canals, we should for the same reason reject the filthy raw sugar, and supply its place with the purified products of the refiner? The parallelism, in a sanitary point of view, between bad water and raw sugar is complete: it is equally so between pure water and refined sugar."

ON THE INFLAMMABILITY OF PETROLEUM AND SCHIST OILS.

By Dr. Robert Peltzer.

(Translated from Dingler's Polytechnic Journal, Vol. 189, page 61, by Dr. Adolph Ott.)

I have lately made experiments on the inflammability of different products of distillation which were derived from Pennsylvania petroleum and bituminous schists from Autun, Dept. Saône and

Loire in France. The same were conducted in the refinery of Messrs. Cogniet, Maréchal & Co., and made by the special request of M. Cogniet. The following are the results of these experiments:

PETROLEUM.		SCHIST OIL.	
Density.	Inflammability. Takes fire at—	Density.	Inflammability. Takes fire at—
0·643	— 5 8° F.	0·769	+ 10·4° F.
0·686	— 5·8	0·791	66·2
0·700	— 2·2	0·805	95·
0·740	+ 59·0	0·814	118·4
0·748	+ 60·8	0·823	140·
0·750	+ 62·6	0·841	176·
0·760	95·	0·851	186·8
0·775	113·	0·880	208·4
0·783	122·	Portion soldifying at 59° F.	206·6
0·792	167·	Crude Schist Oil of 0·882.	82·4
0·805	194·		
0·822	230·		
0·831	203·		
0·848	158·		
0·850	136·		
Crude petroleum of 0·802	59·		
Heavy oils from the distillation of kerosene.	343·4		
Paraffine of melting point 129·2° F.	429·8		

The oils were heated in a small capsule over a water or paraffine bath, a thermometer being inserted in the oil, and a thin burning wick being held over the same.

The petroleum oils which were experimented upon, were very differently obtained, a part of them were gathered directly from the cooling worms in refineries, others were obtained by fractional distillation in small retorts, and still others by evaporation of specifically light mixtures.

The two first samples of the density of 0·643 and 0·686 already took fire at 5·8° F., henceforth the inflammability diminishes till the density of 0·822 is reached. From this point we again see it increase. This remarkable fact is easily explained, when we consider that the high temperature which is necessary to distil the oils of 0·822, is sufficient to produce a partial decomposition of the higher boiling oils in the retort.

This admission is sufficiently confirmed by the experiment. When the distilled oils had reached the density of 0·822, the fan under the retort was drawn out. In producing a light oil of 0·800, distillers generally gather only the portions which come up to this point; the first fractions which are used with the illuminating oil possess a specific weight of 0·750; the mixture does not then take fire below 96·7° F. The remainder in the retort may be heated to 343·4° F. before it is inflamed by a burning wick. When, however, after the distillate had reached the specific gravity of 0·822, the heat was increased, as it is done for the production of lubricating oils; the inflammability was also increased, as is seen from the foregoing table.

Refined paraffine of a melting point of 129·2° F., could be heated to 429·8° F.; it then took fire, but without a prior decomposition being noticed, which obviously had taken place in the distillation of the heavy oils and crude oil containing paraffine masses.

The schist oil samples were obtained from a distillation on a small scale. The same was carried out in a cast iron retort of 2½ gallons capacity on naked fire. The oils were purified and from Autun. It is striking that the latter are a great deal more inflammable than the petroleum oils of the same density. Prof. Maroc, of Stuttgardt, also indicates the inflammability of a schist oil, which he does not designate further than as being at 63·5° F.

It is highly probable that a similar decomposition goes on in the distillation of schist oils at an elevated temperature, only in a less striking manner than is the case with petroleum. Unhappily, my choice was very limited, and I was specially in want of the distillates from the crude heavy oils for the production of lubricators, otherwise the decomposition of the schist oils could have been more precisely determined.

*Upon this decomposition a process could be founded for changing the heavy petroleum oils by a high heat (at least partially) into illuminating oils, as Mr. Breitenlohner, of Chlumetz, Bohemia, has already done with heavy peat oils.**

This principle has already found application in the refinery of Messrs. Cogniet, Maréchal & Co., as yet, however, on a very limited scale.

From the foregoing table we notice a diminution of the inflammability with the increase of density in case no decomposition has

* Polytechnic Journal of Dingler, CLXVII., page 378.

yet taken place by too elevated a temperature; but even an approximate relation between these two points is, however, not perceivable. If the greater or less inclination of the oils to inflame, was simply dependent upon the boiling points of the single fractions, which would represent more or less constant mixtures of hydro-carbons of the series $C^{2n} H^{2n} \times 2$, as isolated by Cahours, Pelouze* and Schorlemmer† than a fixed relation between the inflammability and density would be the necessary consequence; this relation is, however, very probably concealed by a different degree of absorption by the various "fractions" of the highly inflammable gases, which are met with in the oils.

A fraction which holds a certain quantity of gas, possesses also a corresponding inclination to inflame.

For making the crude petroleum applicable and perfectly safe for the heating of steam boilers, it would be necessary to separate all the oils until the density of 0·783 is reached, and then to free it from the absorbed gases. Though oils may yet be present, which are inflammable from 1·22 to 1·67° F., their per centage is so small that the fluid will bear a heat of 176 to 212° F. without there being any danger of explosion. The oil below the density of 0·783 could be sold partly as kerosene, partly as essence for the so-called magic lamp.

LECTURE-NOTES ON PHYSICS.

By Prof. Alfred M. Mayer, Ph.D.

(Continued from page 258).

§ VI. *Capillary Attraction.*

The phenomena of capillary attraction consist in the elevation or depression of the surfaces of liquids along the line of contact with the walls of the vessels which contain them; in the ascent or depression of liquids between slightly separated plates, or in tubes of such small internal diameters as to approach to the dimensions of a hair; whence the name of capillarity, from *capillus*, a hair.

These effects are due to the attractions of the molecules of the

* Pelouze, Comptes Rendus, Vol. LVI., page 505; Vol. LVII., page 62.

† Schorlemmer, Chemical News, 1863, page 157.

liquid for each other combined with the attractions existing between them and the molecules of the solid.

Generalization of the Phenomena of Capillary Attraction.

1. The ascent or depression of the liquid is inversely as the diameter of the tube; provided that this diameter does not exceed two millimêtres. In tubes over twenty millimêtres in diameter, there is neither elevation or depression of liquids.

2. The phenomena are independent of the pressure to which the apparatus is subjected; being the same in vacuo as in compressed air.

3. They do not depend on the thickness of the tube; hence the action of the tube is limited in its effects to insensible distances.

4. The phenomena vary with the material of the tube, and with the nature of the liquid; thus, in a tube of glass, water rises above and mercury is depressed below the level of the outside liquid. The following table of the experiments of M. Frankenheim, gives the heights in millimêtres to which different liquids rise, at a temperature of 0° C., in a glass tube of 1 millimêtre in diameter.

LIQUIDS.	DENSITY.	ELEVATION.
Water	1·000	30·73
Formic Acid	1·105	20·40
Acetic Acid	1·290	17·02
Sulphuric Acid	1·840	16·80
Solution of Potassa	1·274	15·40
Petroleum	0·847	13·90
Spirits of Turpentine	0 890	13·52
Acetic Ether	0·905	12·20
Alcohol	0·821	12·10
Alcohol	0·967	14·54
Ether	0 737	10·80
Bisulphide of Carbon	1·290	10·20

5. When the liquid *wets* the tube, it rises above the level of the

liquid outside the tube; and in this case the surface of the elevated liquid is *concave.*

Example. Water in glass tube.

6. When the liquid *does not wet* the tube, it is depressed below the surface of the exterior liquid; and in this case, the surface of the liquid in the tube is convex.

Example. Mercury in tube of glass.

7. When the liquid in the tube has a plane surface, there is neither elevation or depression.

Example. Water in a tube of steel.

These facts are readily explained by the atomic theory, of which they are a beautiful illustration and a natural deduction.

(*a.*) An attraction exists between the neighboring molecules of a liquid, and between the molecules of a liquid and of the contiguous solid.

(*b.*) This force decreases very rapidly as the distance between the molecules increases, and becomes null when that distance exceeds *the radius of sensible attraction.*

(*c.*) The attraction existing between the molecules forming the surface of a liquid, and those extending below the surface as far as the radius of sensible attraction, produces a *molecular pressure*, or tension, on this surface, whose effect has to be added to the pressures produced by gravity and the atmosphere.

(*d.*) The molecular pressure is greater with a convex and less with a concave than with a plane liquid surface.

The truth of the four preceding postulates, is made clear by what follows:

Let S S′, Fig. 3, be a liquid surface of any form. M is a molecule on the surface; M′ is a molecule distant from the surface less than the radius of sensible attraction; and M″ a molecule whose distance from the surface equals the radius of sensible attraction; while all molecules between S S′ and R R′ are distant from the surface less than the radius of sensible attraction.

The molecule, M, on the surface, is attracted downward by all the molecules contained in the portion of sphere which has for its radius M P, the radius of sensible attraction. The effect of all these attractions on M will be a resultant in the direction M P, perpendicular to the surface.

The molecule, M′, is attracted by all the molecules contained in the spherical portion A B C, which we can divide into three parts by

three equidistant planes, A B, P Q, A′ B′, parallel to the surface, S S′. The attraction produced by A B P Q, is destroyed by the attraction of P Q A′ B′, and therefore the molecule M′ is drawn downward as though it were attracted only by the liquid contained in A′ B′ C, which gives a resultant, P′, also perpendicular to the surface, but less than P.

The molecule, M″, whose distance from the surface equals the radius of sensible attraction, and all other molecules placed at greater distances, are equally attracted on all sides, and therefore they produce no tension in the surface-film of the liquid, which has for its thickness the radius of sensible attraction.

The influence of the curvature of the liquid surface on the molecular pressure.

Let M′, Fig. 4, be a molecule at a distance M H from the surface S S′ of the liquid. With M as a centre, draw a sphere whose radius M′ P equals the radius of sensible attraction.

If the surface is a plane, A B, the attractions of the liquid in A B P Q are destroyed by those produced by the symmetrical portion below, A′ B′ P Q, and there remains for resultant only the action of A′ B′ C.

Suppose the surface concave and D H E; if we draw through H′ the symmetrical surface, D′ H′ E′, it is evident that the attractions of the molecules comprised between D H E P Q and of those contained within D′ H′ E′ P Q equal and oppose each other, and there remains only the attraction of D′ H′ E′ C on M′, which is less than when the surface was a plane.

If the surface is convex, and is represented by K H L, draw the symmetrical surface, K′ H′ L′; then the efficient attracting portion of the liquid will be increased and represented by K′ G′ L′, and consequently the molecular pressure is greater with a convex than with a plane surface.

We can now explain the rise and depression of liquids in capillary tubes.

When the surface of the liquid in the tube is *concave*, the molecular pressure on the liquid in the tube is less than the pressure on the liquid outside the tube, and therefore the liquid rises in the tube to a height which measures the diminution of pressure produced by the concave surface.

When the surface of the liquid in the tube is *plane*, there is

neither elevation or depression, for the pressures are the same on the surfaces of the liquid inside and outside the tube.

When the surface of the liquid in the tube is convex, the molecular pressure on the liquid in the tube is more than the pressure on the liquid outside the tube, and therefore the liquid column is depressed in the tube below the level of the outside liquid, and the depth to which the column is forced below this level, is the measure of the pressure produced by the convex surface.

As we have seen that the elevation or depression of liquids in capillary tubes, is due to a diminution or increase of molecular pressure, produced by a concave or convex surface, it remains, to render the explanation complete, to show the cause of the special figure of each surface.

Cause of the (1) plane, (2) concave, and (3) convex surfaces of liquids in capillary tubes.

Let D A in Figs. 5, 6 and 7, be the vertical surface of a solid plunged in liquids, whose surfaces are M L. Let M be a molecule of the surface of the liquid contiguous to the plate. This molecule is attracted by all the molecules contained in the quarter-spheres D M C and A M C, whose radii are equal to the distance of sensible attraction; giving as resultants M S and M S′, while the resultant of the attractions of the liquid on the molecule, M, will be M. P.

Three cases can present themselves.

1. If the resultant, M P, Fig. 5, is *twice* M S, or its equal, M S′, the effect of these three attractions on M will be the resultant, M R; which being perpendicular to the liquid surface, the fluid will remain *horizontal*, for the surface of a liquid is always perpendicular to the forces acting on it.

2. If the resultant, M. P, Fig. 6, is *less than twice* M S or M S′, the three attractions will result in M R, which will produce a *concave* surface M L′, inclined against the plate.

3. If the resultant, M P, Fig. 7, is *more than twice* M S or M S′, the resultant of the three attractions on liquid contiguous to solid will be M R, which will, for the reason given above, produce the surface M′ L′, which will be *convex*.

The above results may be expressed concisely as follows:

I. On the free surface of every liquid there exists a molecular pressure from without inward, which always adds its effect to that produced by gravity and the pressure of the air.

II. The intensity of this molecular pressure varies with the form

of the surface, being greater when the surface is convex and less when concave, than when it is plane.

III. The form of a liquid surface in a tube, depends on the relative amounts of attraction existing between the molecules of the liquid and the molecules of the solid and of the liquid.

1. When the attraction between the molecules of the liquid is *twice* as great as the attraction between the molecules of the liquid and those contained in an equal portion of the solid, the surface in the capillary tube is *horizontal*.

2. When the attraction between the molecules of the liquid is *less than twice* that existing between the molecules of the liquid and solid, the surface in the tube is *concave*.

3. When the attraction between the molecules of the liquid *is more than twice* that between the molecules of the liquid and solid, the surface in the tube is *convex*.

IV. When the surface of the liquid in the capillary tube is (*a*) *horizontal*, it is in the same plane with the exterior liquid. (*b*) *concave*, it is above the plane of the exterior liquid. (*c*) *convex*, it is below the plane of the exterior liquid.

V. The amount of elevation or of depression of the same liquid in tubes of the same material, is inversely as the diameter of these tubes. This is known as the law of Jurin, after the philosopher who established it; and with the aid of the table already given, we can by means of it readily calculate the heights to which different liquids will rise in glass tubes of various dimensions, contained within diameters of two millimêtres to a few hundredths of a millimêtre.

The reason of this law is as follows. The force which elevates or depresses the liquid columns in the tubes depends evidently, from what has preceded, upon the number of the molecules on the surface of the liquid contiguous to the sides of the tubes. Therefore, the forces of elevation or of depression are as the interior circumferences of the tubes, and the forces are measured by the quantity (or weight) of liquid elevated above or depressed below the level of the liquid exterior to the capillary tube. Therefore, let h and h' be the lengths of liquid columns elevated or depressed in tubes whose interior diameters are respectively d and d'. Their interior circumferences are πd and $\pi d'$. δ being the specific gravity of the liquid, the weights of the columns elevated or depressed will be $\frac{1}{4}\pi d^2 h \delta$, and $\frac{1}{4}\pi d'^2 h' \delta$. These weights are equal to the forces

which produce the elevations or depressions of the liquid columns, and these forces being to each other as the interior circumferences of the tubes, we have

$$\pi d : \pi d' :: \tfrac{1}{4}\pi d^2 h \delta : \tfrac{1}{4}\pi d'^2 h' \delta$$

or

$$d : d' :: h' : h$$

which is the expression of the law given above.

Experiments.—The apparatus with which Gay Lussac verified the above law, explained and used.

If two squares of plane glass, touching along two vertical edges, are opened to an acute angle and placed in colored water, the liquid will rise between the plates, forming an equilateral hyperbola, and therefore the liquid at various points stands at heights inversely as the distance of the plates at these points.

The relation which exists between the form of the surface which terminates the capillary column and its vertical distance above the plane of the exterior liquid, is beautifully shown by the following experiment, which, with those above cited, can be readily thrown on a screen by means of the lantern and erecting prism of Prof. Morton (see *Journal of Franklin Institute*, Vol. LIII., p. 406). A large glass tube has connected with it a capillary tube, as shown in Fig. 8. Water, colored with carmine, is poured into the larger tube until its level reaches, say, A, and the liquid in the capillary tube just attains the top, S, and in these circumstances, will there form a *concave* surface. Now, on pouring into the large tube more liquid, the concave surface becomes flatter and flatter as the liquid rises in the tube A, until, when the surface rises to B on the same level as S, the terminal surface at S is *a plane*. When liquid is further added until the surface reaches C, at a higher level than S, the capillary surface at S is *convex*.

When S is concave, the molecular pressure on this surface is less than on A by the pressure of the column from the level A to S. When S is plane, equality of pressure exists in both tubes, and therefore the liquid surfaces are in the same plane. When S is convex, more molecular pressure is on S than on C, by the column from S to the level C,

Professor Plateau, of the University of Ghent, has made a series of very important investigations in molecular physics, which are contained in a series of papers entitled, "*Experimental and Theoretical Researches on the Figures of Equilibrium of a Liquid Mass*

withdrawn from the action of Gravity," translated and published by the Smithsonian Institution, in the Reports of 1863, *et seq.* The fifth series of these investigations (Smith. Rep. 1865), contains a research on the molecular pressure exerted by liquid films, with applications to capillary action; and so interesting has this investigation appeared to us, that we thought it proper to present a rather full abstract from Prof. Plateau's paper.

Pressure exerted by a spherical film on the air which it contains. —Application.

"The exterior surface of a laminar sphere being convex in every direction, the pressure which corresponds to it is greater than that of a plane surface, and consequently the resultant of the pressures exerted in any point of the bubble by the two surfaces of the latter, is directed towards the interior; whence it results that the bubble presses on the air which it encloses. It is, indeed, well known that when a soap-bubble has been inflated, and while it is still attached to the tube, if the other extremity of this last be left open, the bubble gradually collapses, expelling the air which it contained through the tube. We see now what is the precise cause of this expulsion.

"But we may go further, and determine according to what law it is, that the pressure, exerted by such a bubble on the confined air, depends on the diameter of that bubble. We can compute, moreover, the exact value of the pressure in question for a bubble having a given diameter, and formed of a given liquid. The pressure corresponding to a point of a laminar figure, has for its expression $A\left(\frac{1}{R}+\frac{1}{R'}\right)$. R and R′, standing for the radii of curvature, P being the pressure which a plane surface would occasion, and A a constant which depends on the nature of the liquid. Now, in the case of the spherical figure, we have $R = R' =$ the radius of the sphere. If, therefore, we designate by d the diameter of the bubble, the value of the pressure will simply become $\frac{4A}{d}$, always, be it understood, neglecting the slight thickness of the film; whence it follows that the intensity of the pressure exerted by a laminar spherical bubble on the air which it confines, is in inverse ratio to the diameter of that bubble.

(To be continued.)

RESISTANCE AND TRANSMISSION OF MOTION.

By Prof. Henry Morton, Ph. D.

There are a number of phenomena more or less directly connected with the effect of high velocity in overcoming resistances, which are commonly regarded as forming a class by themselves, and requiring a special hypothesis for their explanation, or if treated in the established method, calling for an exercise of faith in a train of reasoning not in itself quite unexceptionable, which is at the least a source of discomfort to ordinary minds.

As an illustration of the phenomena to which we allude, we may cite the oft-quoted experiment of shooting a tallow candle through a pine board, the piercing a slate with a pistol ball, without cracking it, &c.

In an able paper by Mr. John C. Trautwine, C. E., entitled "Remarks on Force, Motion, and Inertia," published in this *Journal*, Vol. XLIV., p. 197, some of these difficult questions are very fully expressed. We will quote, for want of space, but one of the illustrations used, although we would strongly recommend the article to all interested, as an accurate and entertaining discussion of a subject which has been inadequately treated by some even of the highest authorities.

After various other and more elaborate illustrations, Mr. Trautwine says: "The ordinary coupling between a locomotive and a heavy train, would break, under the action of an engine capable of imparting to the train at one impulse, a velocity of forty miles an hour; yet it safely transmits the same amount of moving force when imparted by a succession of milder impulses," and further on, "it would seem, that *moving force will of itself* sever mediums through which we may attempt to *transmit* too much of it, to *unresisting matter*, as well as to resisting force."

We believe that the obscurity of this subject will be greatly relieved, if only a little thought is given to the nature of those molecular forces which are the most usual active agents in the resistance and the transmission of motion.

It will then be seen that these are forces which differ in nothing but their range of action, and intensity, from gravity, or other like energies, and may be fairly compared with them in their mode of action.

There is, however, another point, which, though self evident, is apt to be overlooked in our study of all forces, and that is their relation to time, in the respect, that the effect of any force must be proportional to its time of action. Thus, if a force is capable of producing a certain effect in one instant, it will do the same twice over in two instants, and can do but half as much as this in half the time.

We should then first regard the particles of bodies as maintained in their relative positions, not by any general and indefinite condition of contact, but by the constant action of certain forces of great but limited power, and exerting this power, not without reference to time, but on the contrary, with entire dependence upon it; so that each element is exerting so much force in so much time, more in more time, less in less time, in a direct proportion.

These general principles being premised, we will presently assume a case involving the transmission of motion, and test our theory in its explanation.

Our conception of this subject will be rendered more easy, however, if we first consider a parallel case in which gravity might take the place of the transmitting or molecular force.

Imagine the earth at rest in space, with a heavy body in contact with it at some point. If, now, the earth received a motion in a direction radial to the point of contact, and away from it, the heavy body would remain in contact so long as this motion was not greater than that of a body falling from a state of rest, *i. e.* (sixteen feet in the first second, and so on.) In other words, the attractive force between the heavy body and the earth (which here represents the molecular force of our actual experiment), is just equal to that which we express by so much matter (the weight of the heavy body), moved sixteen feet from a state of rest; this power being put forth in the time of one second.

If, now, we required a greater force to be transmitted by this attraction of gravity, either by asking it to move a greater mass at the same rate (as by connecting the heavy body by a string, with another so placed as to be free from all resistances to motion), or by demanding a higher velocity (as by supposing the earth to move more than sixteen feet in the first second), we should simply rupture the connection between the earth and heavy body. By keeping within the limits of the *transmitting* force (which in the above case was gravity, but might be any other), we can transfer part by

part, any amount of force to the second body, which will be converted into motion in it, and be so stored up and accumulated without loss, all resistances being removed.

We will now take up an actual case of transmission to which our principle should supply an explanation.

A weight, W, rests without friction on a level plane, and a power, P (derived say from the action of gravity upon a heavy body), is caused to act upon it by means of a cord passing over a fixed pulley.

In an instant of time, gravity exerts a certain pull upon the heavy body, which we may assume to be transmitted instantly to the first point of the cord; but how is it to travel along the cord? It is clear that the only mechanical connection between the successive points of the cord, is their *cohesive attraction for each other;* it is then by what we may be allowed to call a *stretching* of this attractive force, that the power, P, can be transferred along the cord to W, and by no other means. Now, this molecular force is as we have already seen, properly expressed by, and in fact constituted of, so much power in so much time. If, then, we draw one of these atoms from another with a force which is greater in the *same time* than that uniting them, a rupture will occur, and so much force only be transmitted as was exerted by the molecular power during the time that the weight was acting upon it.

The questions and conditions here noticed, lead us to another cognate subject of similar difficulty, and amenable to similar treatment; we allude to the relations between the moving force and the work done by a moving body.

We say and know that the *vis viva* or work done by a moving body, varies with the square of its velocity, while we know by our previous reasoning, that the force expended in giving it that velocity, only varies with the velocity itself. Thus the force of gravity will give a falling body a double velocity in a double time, during which it must have exerted a double force upon it. Here, then, we have a double force, doing a quadruple work. Is this because by some wonderful and recondite property inherent in "velocity," the double power has been indued with an again doubled efficiency? Many writers leave us to think so; but we, on the contrary, believe that the work done *only seems to increase* more rapidly than the power implied in the increased velocity, by reason of a *loss of efficiency* in the resistances, in the overcoming of which the "work" consists, and in fact, that work in this sense, is no true measure of force.

As we have before seen, the molecular forces (which are those that most commonly play the part of resistances) as well as all others, exert powers proportional to the times of their action. If, then, a moving body with a certain velocity, overcomes a certain number of these resistances, or, for example, penetrates a medium to a certain depth, before its motion is arrested, it has overcome so many resistances, each acting for such a length of time. If, now, the same body with a double velocity, meets the same medium, it will penetrate each resisting element in half the time, and so receive from it but half the resistance it experienced before. If, then, its total force were *only equal* to what it was at first, it would go twice as far, or overcome twice as many resistances; because each of them would be but half as effective as at first. But as we know the double velocity implies a double total force, and thus, considering the doubling of the force and the halving of the resistances, we see why the number of these overcome, or the work done, should be four-fold.

Similar reasoning would apply to the case of a body resisted in its upward motion by the force of gravity. A double velocity would give a four-fold height to its upward path, because, traversing each distance in half the time, gravity would exert but half its former effect within the same space, and so on, as before followed out.

The body would come to rest when exposed *for a double time* to the resisting force of gravity.

It may be objected that the time of action is not the true measure of a force, but rather the distance which it causes a body to move in a given time. But that this is not so, will be seen when we consider that any velocity once implanted in a body, needs no force to maintain it, so that all the motion afterwards executed by reason of that element, is a clear gain having no equivalent of expended force as its representative. Thus, a falling body acquires during the first second, a final velocity of thirty-two feet per second. If gravity then ceased to exist, it would still travel this distance in the next second, while if the force still exist, and is to be expressed by the motion produced, we would have it responsible in the first second for sixteen feet, and in the next for forty-eight.

It is precisely this which introduces the philosophical error into the method of estimating force by the product of mass, into the square of the velocity.

But again, it may be said, the true measure of a force is the heat it develops, and this, as we know, varies with the square of the velocity. We would reply that all development of heat is unquestionably of the nature of overcome resistances. Thus the vibratory motions given to the atoms of bodies, are given in opposition to and by overcoming their molecular forces, and therefore, as in other cases, these forces will each individually oppose a *shorter* resistance to a body with high velocity, and thus render a greater number of their companions necessary to counteract its motion. In other words, the previous explanation may be applied word for word to this case.

Or, we may say, the change produced in the individual atoms of a resisting medium, which we have heretofore called overcoming of their resistances, *is* heat. Therefore, if a double velocity overcomes a four-fold number of resistances, it develops a four-fold amount of heat.

In conclusion, we would again remark that the foregoing discussion is in nowise intended as suggesting a new system of mechanics. The rules at present employed are perfectly correct in their working, and more convenient in form, we think, than any which could be established on another basis. Like many rules and methods in mathematics, they are without reference to the rationale of the process, but accurately fitted to its requirements. Thus, for example, to take a simple case in arithmetic, in place of dividing one fraction by another, we invert the second and multiply. This is perfectly correct and unobjectionable as a method of obtaining certain results, but if the final expression (e. g. $\frac{1}{2} \times \frac{3}{1}$) were regarded as a rational explanation of some process (the inverting step being ignored), it could not well convey a very true or satisfactory impression. So, when we calculate the efficiency of various forces by the formula $f = mv^2$, we are simply transferring one v from the denominator of a fraction expressing the resistance, to the numerator of the quantity expressing the force, which we have a perfect right to do, provided that we recognize this as a *mathematical process*, and not as the expression of a *physical fact.*

Our object in writing the above, is to make clear that this *is* the actual state of the case, and thus, in this and the other points noticed, to offer to those who may feel the appetite for such a supply, the reasoning which has satisfied in ourselves the craving after a rational account of things that had a certain air of paradox about them, as commonly enunciated.

Sunlight & Moonlight

Oct. 3rd 11h 23'.

Oct. 3rd 11h 51'.

EDUCATIONAL

SUNLIGHT AND MOONLIGHT.

A Lecture delivered at the Academy of Music, before the Franklin Institute, on May 23d and June 6th, 1868.

By Prof. Henry Morton, Ph. D.

(Continued from page 277.)

Such, then, are some of the facts which are revealed to us by the light reflected from the moon's surface, and so much do they tell us of her past history and present condition. But such information, and similarly acquired, we also receive from other sources, as in the case of our companion worlds, the planets, whose light, like that of the moon, is but reflected sunlight, modified by, and thus informing us of their special conditions of surface.

As regards the interior planets Mercury and Venus, their propinquity to the sun and their intense illumination, together with other causes, such as their small size, renders our observations most meagre and unsatisfactory, but when we direct our view to Mars, we see much that is of interest, and has a meaning which we may hope to interpret.

We find there a condition of things quite antipodal to that of the lunar surface. The planet Mars is undoubtedly wrapped in an atmosphere loaded with vapor and clouds, and possesses a surface diversified by oceans and continents, lakes and peninsulas. The changes and the observations produced by the movements, formations and dispersions of clouds, makes the determination of the permanent features of this planet very difficult, but yet by a careful comparison of various sets of drawings, such as those of Beer and Madler, made in 1830, those of Father Secchi, made in 1858, and the latest by Mr. J. N. Lockyer, in 1862, we see clearly that certain general markings are permanent after years have elapsed, and regain their original appearance after being temporarily obscured and concealed.

Such, for example, is the part marked *a*, on Plate 5, and known as the Scorpion, and the part marked *b*, which we might well call,

by analogy, the Atlantic, and *c*, the Mediterranean. The formation and grouping of clouds on the other hand, causes certain appearances which we learn to recognize as unconnected with the geographical constitution of the planet, by reason of their evanescent character.

A striking instance is shown in the accompanying plate, which is taken from a series of drawings by Mr. Lockyer, published in the *Memoirs of the Royal Astronomical Society*, 1863, p. 179.

Here we have two views, taken at the interval of half an hour, one bearing date October 3d, 11 h. 23′, the other October 3d, 11 h. 51′.

In the first, it will be observed that the area indicated by *x*, is devoid of all markings except a small rounded shade; in the second, this shade has developed into a chain of three connected lakes. In the first case, we suppose that the region was covered and concealed by a mass of cloud, which subsequently dispersing or perhaps falling as a snow storm, or as a rain shower, left the existing features of the planet evident to our eyes.

The growth and decrease of the snow zones, which surround either pole, and which creep out in the winter of each hemisphere, and melt away again as the time of summer comes to each, is also a curious evidence of a series of meteorological and climatic phenomena, wonderfully in accordance with our own terrestrial experience.

The consideration of these things gives us a vivid impression of the wonderful revealing power of the agent, which we are now studying.

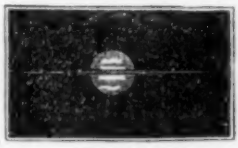
We often admire the wonders of the electric messenger and his timeless flight, annihilating distance, and bringing together the ends of the earth, but what are these achievements compared to those here accomplished.

The electric fluid flashing along the cable-covered wire, can give warning to the coast of England, that a tempest has begun its march across the broad Atlantic, and although now a thousand miles distant, will soon be howling across the chalk cliffs of the island and thundering into its bays, but here the swifter footed light, flashing out from the sun across the fields of space, and turning back to us from its momentary resting place on the continents, or oceans, the mountain summits or their cloudy crowns, the polar snows or equatorial deserts, of this distant planet, tells how a tornado of snow and sleet is at almost the same instant sweeping over that globe *thirty-five millions of miles away.*

The picture which is now thrown upon the screen, shows you at a glance, prepared as you are to interpret the meaning of its various indications by what you have seen before, what we can learn as to the physical constitution of the planet Jupiter. You see a series of belts of an irregular form, but following the line of the planet's equator, and these by their form and by their changes, indicate that when we look towards this planet, we see little more than the cloud masses of its watery atmosphere, drawn out into such zone-like lines, by the action of trade winds.

You now see in turn, the planet Saturn, with his eight satellites and his rings. These last, which have since their discovery been among the mysteries of the universe which seem to defy human ingenuity, are now believed to be, not continuous masses of matter, but troops of satellites, minute, innumerable, closely arrayed, yet moving in independent harmony. A choral band, sweeping in majestic measure round their ruling centre and primary.

Among our reasons for so regarding them, the most prominent are these: When they have been in such position as to be seen edgewise, breaks have been observed in their substance, as is shown in the figure. Now, a break in a continuous ring, it is easy to prove, must result in its speedy destruction of form and coagulation into a globe, without the possibility of a restoration to the annular shape, but in a swarm of circling planets, such gaps might naturally occur from time to time, and close again without disturbance.



Other changes inconsistent with the continued existence of a continuous mass, are also noticed, such as the longitudinal splitting of the rings, and it is also believed that a scattered interior mass of these minute planets has formed within the inner ring in modern times, being the result of collision and consequent in-falling of the revolving fragments. This cloud, called "the veil," was first seen in 1850 by Bond and Dawes, with difficulty, in their powerful instruments, but is now easily discerned with an objective of but four inches aperture.

(To be continued.)

LECTURES ON VENTILATION.

By Lewis W. Leeds.

Second Course, delivered before the Franklin Institute, during the winter of 1867–68.

(Continued from page 284.)

The surgeons in charge of the splendid hospitals built in and around Philadelphia during our late war, made verbal and written protests against having these hospitals ventilated in winter, because the form adopted by the Government was a little varied (for the purpose of adapting it especially to these temporary buildings) from the time-honored forms to which they had been accustomed from their childhood up. There is one great comfort to you in this characteristic of your regular physicians:—if your doctor was to offer you a medicine you were not accustomed to, do not have the slightest hesitation in taking it, for you may rest perfectly assured that it has been tried in every hospital in the land, and that it is in common use in every other city in the Union before it is offered to you.

It seems to me a little unfortunate that our physicians have fallen into this quiet, easy way of gliding around so elegantly, with their hands in their pockets and their brains in their medicine boxes. Now, this is not because these physicians do not really know better, because, if you were to attend their lectures you would find them discoursing very eloquently on the great importance of the functions of respiration, and the importance of pure air in all cases.

Note.—If you should happen to find the Professor lecturing thus in a close, unventilated room, smelling very badly, this, you must remember, is a strong argument of their appreciation of pure air—as you know doctors never take their own medicine. Or, if you were to go into the office of any one of them, and take up any of the standard text books on their tables, you will find that all eminent medical writers lay very great stress upon the necessity for the most perfect ventilation at all times. They consider it of greater importance than eating, drinking and medicine in the prevention and cure of disease. For instance, here is Carpenter's Human Physiology, which, in summing up a very elaborate article on Respiration, says, page 326:

"Thus it appears that in all climates, and under all conditions of life, the *purity of the atmosphere* habitually respired is essential to the maintenance of that power of resisting disease which, even more

than the ordinary state of health, is a measure of the real vigor of the system. For, owing to the extraordinary capability which the human body possesses of accommodating itself to circumstances, it not unfrequently happens that individuals continue for years to breathe a most unwholesome atmosphere without apparently suffering from it, and thus when they at last succumb to some epidemic disease, their death is attributed solely to the latter, the previous preparation of their bodies for the reception and development of the zymotic poison being altogether overlooked.

"It is impossible, however, for any one who carefully examines the evidence, to hesitate for a moment in the conclusion that the fatality of epidemics is almost invariably in precise proportion to the degree in which an impure atmosphere has been habitually respired, * * * and that by due attention to the various means of promoting atmospheric purity, and especially efficient ventilation and sewerage, the rate of mortality may be enormously decreased, the amount and severity of sickness lowered in at least an equal proportion, and the fatality of epidemics almost completely annihilated. And it cannot be too strongly borne in mind, that the efficacy of such *preventative* measures has been most fully substantiated in regard to many of the very diseases in which the *curative* power of medical treatment has seemed most doubtful, as, for example, in cholera and malignant fevers.

"The practical importance of this subject may be estimated from the startling fact, which inquiries prosecuted under the direction of the Board of Health have recently brought to light, viz: that the *difference* in the annual rates of mortality between the most healthy and the most unhealthy localities in England, amounting to no less than 34 in 1000, is almost entirely due to zymotic diseases, which might be nearly (if not completely) exterminated by well-devised sanitary arrangements. The *lowest* actual mortality is 11 per 1000, while the highest is 45 per 1000, and between these extremes there is every intermediate degree of range. But what may be termed the *inevitable* mortality, arising from diseases which would not be directly affected by sanitary improvements—is a *nearly constant* quantity throughout, namely, the 11 per 1000 of those districts which are free from zymotic diseases.

"The average mortality of all England, in ordinary years, is about 22 per 1000, or just double that to which it might be reduced; so that taking the population of England and Wales (as by the last

census) at nearly 18,000,000, the average annual mortality must be 396,000, of which only 198,000 is *inevitable*, an equal amount being *preventable.*"

Thus you see these physicians tell you that one-half of all the sickness and death are "*preventable.*" They don't say they can *cure* them with their medicines, but that they are preventable, and that the great means they recommend for accomplishing this wonderful work is pure air—ventilation. But, although they have said this, and re-said it, for the last fifty years, yet it has seemed, as Dr. Hamilton has said, a herculean task to make the public at large comprehend it. So that a whole life spent in teaching the value of pure air has seemed to be a whole life almost wasted.

The extracts that I have just read were written more than ten years ago. But the very careful investigations that have been since conducted by many able and scientific hygienists, only more fully prove these assertions. Perhaps no city presents a stronger contrast between her healthy and unhealthy wards than does the city of New York.

Dr. Harris says of one of the most densely populated wards of New York, the Seventeenth, that the death rate has been for several years less than 17 to the 1000, and even during the terrible heat of July, '66, the uniform low mortality of that ward was scarcely affected. The death rate in this ward, with its 27,000 inhabitants, was, during the six months ending October 1st, (including the cholera summer) only 16⅓ to the 1000. In the same period the mortality in the notoriously foul Sixth Ward was 54 to the 1000. And although the death rate of Philadelphia is exceedingly favorable, by comparison with some other cities, as, for instance, New York, where it is about 30 to 33, while in Philadelphia it was but 20 deaths to the 1000 of population, yet, you see even that is nearly double what it should be—that it would only be 11 per thousand if we could only avoid those zymotic diseases, or such as are caused exclusively by foul air poisons.

And I believe with an extra ton of coal for each family, and an extra blanket for each bed, so that every chamber might be opened, this night, the one-quarter of one inch, to-morrow night two-quarters, and the next night three-quarters, and so on until every chamber could be kept the whole night in a pure and wholesome condition, and never after closed, we could do much towards saving the 6000 or 7000 lives due to this proper death rate of 11 to the 1000.

But now I have a word to say to you, the people that employ these physicians. They have a good deal of human nature about them after all—they are not so very different from the people amongst whom they live and by whom they are employed. And now, I don't suppose there is a city in the United States in which a physician has to be more exceedingly careful of his *reputation* than in this very city of Philadelphia. And I happen to know something of the reasons for omitting to prescribe, more frequently, fresh air as the medicine most needed for their patients. How many of you, if, being sick, were to have a physician to call frequently, and just say to you. "All you need is more fresh air," would you not say, in your mind (if not out of it), "Well, I think I can attend to getting a little fresh air myself, without paying that doctor two dollars per day for telling me that, and I think, upon the whole, I will get some doctor that will do something for me." So you will probably send for some man you have heard of, as making some wonderful cures of some friends, and if he should happen to be a regular shrewd humbug, he would make a wonderful account of your disease, and finally tell you he thought he had something that would just suit your case, and, as before illustrated, would commence pouring turpentine or kerosene oil on your fires, by which he would create a great smoke and temporary blaze, and this would induce you to exclaim, "What a wonderful man! *he* does something;" and if he could get you out into the fresh air, *that* would soon cure you, perhaps, while you would be giving all the credit to his medicine, and the dollars to him for his trash.

I know some physicians, of most excellent good common sense, who have ideas of their own, and independence enough to express them, and have much more faith in good hygienic rules and regulations, who prescribe pure air, pure water, good wholesome food, and plenty of exercise, but seldom prescribe medicine. These men would have to beg their bread if they had to depend exclusively on popular custom for their living.

And now let us take a new start. Let us put our shoulders to the wheel manfully. We have made a most excellent beginning during the year 1867, and our journalists, too, could they be induced to give a line or two every day for some good hints as to the value of, and the best means of obtaining pure air, such results might be obtained as would astonish the world, and would give one of the grandest examples of hygienic reformation ever recorded.

(To be Continued.)

Franklin Institute.

Proceedings of the Stated Monthly Meeting, September 15th, 1868.

THE meeting was called to order with the Vice-President, Mr. Coleman Sellers, in the Chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported the donations to the Library received since the last meeting of the Institute, from the Royal Astronomical Society, the Royal Geographical Society, the Royal Institution, the Society of Arts, the Chemical Society, the Zoological Society, the Statistical Society, the Institute of Actuaries, London; the Association for the Prevention of Steam Boiler Explosions, Manchester, England; the Geological Survey of India, Calcutta, India; l'academie des Sciences, la Société d'encouragement pour l'industrie Nationale, Paris; la Société Industrielle, Mulhouse, France; der Osterreichen Ingenieur-veriens, der K. K. Geologischen Reichsanstalt, Vienna, Austria Mussée Teyler, Haarlem, Holland; the Smithsonian Institution, Hon. Charles O'Neill, Frederick Emmerick, Washington, D. C.; the Mercantile Library Association, San Francisco, California; the Illinois and St. Louis Bridge Company, St. Douis, Missouri; William F. Roberts, Bethlehem, Pennsylvania; B. H. Bartol, Esq., and Frederick Fraley, Esq., Philadelphia.

The Standing Committees reported their minutes.

The report of the Secretary on Novelties in Science and Art was read. After which the meeting on motion, adjourned.

HENRY MORTON, *Secretary.*

Bibliographical Notices.

On the Construction of Iron Roofs. By Francis Campin.

We have received, from Mr. Van Nostrand, (192 Broadway, New York,) what we believe to be the first example of a book printed throughout by the Photo-Lithographic process, a fact that deserves more than a passing notice. Of course, this process can only be applied in the case of a reprint, and produces, from necessity, a

copy that would satisfy the most exacting Chinaman. None but an expert would dream that this book was printed by other than regularly set-up type. The letters are clear, and stand out beautifully upon the fine toned paper upon which they are printed. The plates appear as fac-simile lithographs, and cannot be made to look better than the original. On the whole, it is a most successful specimen of the new art of Photo-Lithography, and the manner of its "get up" is creditable, in the highest degree, to its enterprising publisher. So much for the appearance and mechanical execution of this book, and we turn now to its contents.

As noticed above, it is a reprint from an English work, that has been most favorably met by the profession. It is divided into three parts: Introductory, Theoretical and Practical.

The first part is a concise statement of the proposed treatment of the subject, under the two topics of "roofs proper" and "domes." In the former class are included those supported by arched structures, lattice girders and trusses. The second comprises the various forms of domes. The author having, in two former volumes, considered the usual arrangements for covering, he restricts himself in the one before us to the analysis of the ribs or girders, with some practical examples.

The second part, upon the "Theory of Roof Construction," is most excellent. Clearly stated, with a simplicity of analysis, by which the tyro in engineering could get a complete insight into the action of forces upon such structures. The subject is entirely divested of the "higher mathematics" some writers seem to consider essential to a proper understanding of mechanical constructions, thus making a "terra incognita" of what ought to be at the finger's end of every engineer. The consideration of the arch form for roofs is incomplete, from the fact that no method of investigating the bending action of a load is given, although this question is not ignored by the author. He considers that it will be amply sufficient merely to calculate the direct thrust at the corner and haunches, methods for doing which he gives on p. 21.

This is all very well for ordinary spans; but it seems to us that in enormous spans like the great roof of the St. Pancras Station, the bending moment is of too serious a nature to be neglected.

The third part is devoted to practical illustrations of the theory developed in the second, merely substituting for trigonometrical expressions their "line values," which simplifies the computations

greatly. We notice one error on p. 31, which could not be avoided, as the process employed for printing must necessarily copy all the errors of the original. The error is not of much consequence, as it is easily discoverable. The notation makes L=ad, when it should be L=ab. The author, in his remarks upon workshop construction, gives thoroughly English views, which are far behind our American practice. Not that Americans have done greater work than the English, but that the American engineer has usually an eye for much simpler details. The author lays much stress upon a proper arrangement for adjusting the parts. This not only necessitates considerable expense in the way of screws and turnbuckles, but also is a dangerous temptation to every mechanic employed in its raising, every one of whom has his idea of "adjustment." In our best American examples, all our roofs are laid out by template, and are either bolted or rivetted, in an unalterable shape, before leaving the shop. When raised, the rafters all pitch in the same plane, to an exactness impossible in trusses adjusted by screws. Then, too, where the English use built sections of "angles," "plates" and "ties," we use solid rolled sections, which simplifies the whole construction. Latterly some of our leading engineers are using wrought iron shoes, instead of cast, a marked improvement on former practice. The plates are full-page lithographs, of a conservatory roof with details, the Broad Street Station of the London and North-western Railway, and the novel roof of the city terminus of the Charing Cross Railway. These three roofs occupy, in all, eight plates.

This is not a voluminous work on roofs, but, as far as it goes, is very complete, and an excellent office companion; and to any engineer who needs a work upon this subject, the contents of which he can apply to his own practice with little labor, we take pleasure in recommending this work of Mr. Campin as, in many respects, the best we have seen.—B.

The Workshop. Edited by Prof. W. Baumer and I. Schnorr and others. No. 8. Published by E. Steiger, 17 N. William Street, New York.

We noticed, some time since, the first numbers of this excellent publication, (which, in its English form, originated with the present year,) and remarked upon the beauty and admirable execution of

the engravings of architectural and other ornaments with which it is filled. (See this *Journal*, Vol. LV., p. 425.) We will at present, therefore, only call the attention of our readers to the fact, that its admirable character is fully maintained, and the present number is, like its predecessors, unrivalled by any publication, both as regards the beauty of its designs or the excellent style of their execution. In addition to its former contents, the work now has, and is to possess in future, if adequately supported, a supplement, containing useful information and advertisements.

The Mechanics' Tool Book, with Practical Rules and Suggestions for use of Machinists, Iron-Workers and others. By W. B. Harrison, Associate Editor of the *American Artisan*. D. Van Nostrand, New York.

This little work will be found of great use by those for whom it is intended, namely, those conducting or employed in small shops, where a few simple tools, such as ordinary lathes and planers, are alone to be found, and must be made to do the work which is to be executed. It does not touch upon the practice of the large shops, where final economy is attained by original large outlay in special machinery for each variety of work, where, to use a familiar expression, somewhat suggestive of the story about "the house that Jack built," a machine is made to make a machine to make a machine.

The author is evidently familiar with the subject he treats, and is evidently relating his own experience, and describing the processes which he has executed with his own hands. Considering its probable readers, one sort of errors with which it abounds are perhaps of little consequence, but it would have done much more credit to its publisher had the number of typographic and grammatical mistakes been reduced to more moderate limits. Thus there are not many pages with less than two, and some, like page 44, with as many as five of such signs of careless proof-reading. E. g. p. 44, "are" for "is" twice, "slope" for "shape" twice, and the word "or" repeated.